THE ART of Dialling:

TEACHING AN EASIE and perfect way to make all kinds of Dials *vpon any plaine plat howsoeuer placed.*

With the drawing of the twelue Signes, and *houres vnequall in them all.*

Whereunto is annexed the making and vse of other Dials *and Instruments, whereby the houre of the day and night is knowne:*

Of speciall vse and delight, not only for Students of the Arts Mathematicall, but also for diuers Artificers, Architects, Surueyours of buildings, free-Masons and others.

By THOMAS FALE.



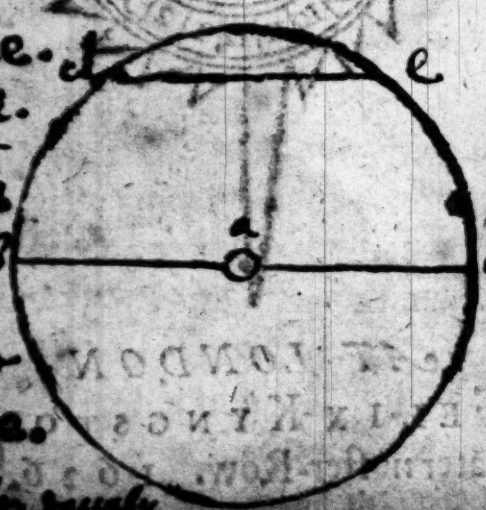
AT LONDON
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SINGVLIS ARTIVM MATHEMATICARVM STVDIOSIS IN CELEBERRIMA CANTABRIGIENSI ACADEMIA, THOMAS FALVS EIVSDEM ALVMNVS, ET VERAE MATHESEOS STVDIOSVS, EXIGVVM HOC GRATI ANIMI MONVMENTVM DD. ANNO. 1593.

Simonis Muri ad lectorem carmen.

Scire cupis certa cur machina tangitur vmbra?
Et brevis aethereum linea signat iter?
Hac, licet euolsas, facili praecepta libella
Tradita, sed voto non leniora tuo.

BRITISH MUSEUM



To the friendly Readers, and namely, *to such as be well-willers to the* Mathematikes.

THe Arts Mathematicall (gentle Reader) in regard of their antiquity and excellency, may be compared with any other of the liberall Sciences whatsoeuer. For *Seth*, who liued in the first age of the world, is commended of *Iosephus*, and *Abraham* of *Berosus*, to haue beene skilfull masters in these mysteries. And the very name importeth, that in olde time these of all other were esteemed worthy to be taught, being called for their excellency *Mathemata*, that is, Sciences meete to be learned. These be *Arithmetike*, *Geometry*, and *Astronomy*, from which this Art of Dialling taketh his beginning: a knowledge also ancient and necessary, and therefore practised by Princes and famous men of former Ages. The first Diall that histories remember, is *Lib.* 2. *cap.* 20. of the *Kings* in the holy Scripture, where the Lord turned the Sunne backe 10. degrees for *Hezekias* sake, whereby it had gone downe in the Diall of *Ahaz*. This *Ahaz* was King of *Ierusalem*, and reigned in the 3200. yeere after the creation of the world, and in the first Olympiade of the Grecians. Afterward, as *Plinie* writeth, *Anaximenes Milesius* the scholler of *Anaximander*, first found out the reason and proportion of shadowes amongst the Lacedemonians, and there taught the Art of Dialling, who liued 200. yeere after the raigne of *Ahaz*, and was a famous Philosopher in *Greece* before *Platoes* time, as *Diogenes Laertius* reporteth. But some affirme, that it was *Anaximander* himselfe that found out this Art, and set forth the first Mappe of the earth.

Lib. 2. *Herodotus* saith, that the Grecians learned this art, and the diuision of the day into 12. houres, of the Chaldeãs. *Diodorus* writeth, that one *Hyperion* first obserued the houres. But if we may beleeue *Macrobius*, it seemeth that this Science came frõ the Egyptians: for they called the Sun *Horus*, which by his motion limiteth to each houre his appointed time.

Lib. 9. *Vitruuius* rehearseth sundry inuentors of this Art of Dialling, as *Berosus* the Chaldean, *Aristarchus*, *Samius*, *Eudoxus*, *Theodosius* with others, who were renowned, and liued many yeeres before the birth of Christ. I neede not here remember *Architas Tarentinus*, who by art made a Doue of wood to flie in the ayre: neither *Archimedes*, who defended *Syracusa* against *Marcellus*, and affirmed that if he had a place to stand on, hee would moue the earth with his engines: both of them no doubt skilfull in this Science.

Plutarch. in Marcel. It was long after the inuention that this Art was known in *Rome*: for in the 12. tables was only mentioned the rising & setting of the Sun, and after certaine yeeres the midday was added. Then in the first *Punike war* the Romanes obtayning victory, there was a Diall brought amongst other spoyles out of *Sicily*. But in processe of time they began to be more common in *Rome*: for 100. yeeres before *Ciceroes* time, the parasite in a Comedy, being hungry, spake against the multitude of Clockes and Dials which were then in the City, *Optans vt suus cuique venter sit horologium.*

Lib. 36. c. 10. *Plinie* also telleth of a Diall placed in the field of *Flora* at *Rome*, which by the space of 30. yeeres had not agreed with the Sun: & the reason was, as he thought, because that either the Sun had taken a new course, or else the earth was slipped from his Centre, wherein at the first it stood, or the stile was put awry by the shaking of the City. Since which times learning spreading it selfe into diuers parts of the world, this Art hath been amongst the rest in great account.

Concerning the profit of this Art, daily experience teacheth, how needfull it is in a well ordered Common-wealth, seeing nothing can be done in due and conuenient season, where this Science is neglected: for the diuision of the day

into certaine parts or houres, (which this Art teacheth) doth limit and allot to each action his due time. This Art being then so ancient, and the vse so necessary, I trust none will thinke this labour superfluous, vnlesse they be rude without ciuility, or such as haue alwaies at hand a Diall of natures framing, of whom this verse seemeth to be made:

Si tuus ad solem statuatur nasus, hianti Morus.
Ore, bene ostendas dentibus, hora quota est.

Many haue promised (but none as yet performed) to write of this Science in our English tongue, which hath bin published in other languages, as *D. Record* long since, *M. Digs*, *M. Blagraue* with other, who, if they would take the paines, I know could doe it with great commendation.

Diuers haue written hereof in the Latin tongue, as *Munster*, *Schonerus*, *Orontius*, *Witekindus*, *Clauius* and others: yet euery one differing from other in precept. Some teach the making of Dials by the helpe of the Globe, as *Gemma Frisius*: some by the Astrolabe, as the same *Gemma Frisius* and *M. Blagr.* which Instruments euery man haue not. Some vse the table of *Sines* and *Arithmetike*, as *Witekindus*, which way as most plain & easie, is obserued in this booke; though in some kinds for want of triall *Witekindus* deceiued himselfe. *Munster* vseth a *Rectificatory* with a circle, which is vnfit for small plats, and faileth in greater, without great heede. *Schoner* wandreth in a wildernesse of lines, that a man knowes not where to begin, or when to end. *Vlmer* hath not the Delineation of all kinds.

Othersome obserue the rules of Geometrical proportion: which order also we thought to haue obserued in al kinds, as we haue don in the South & North erect declining, but that sundry precepts of the same thing would haue bred tediousnes and trouble to the learner, and the cutting of the Figures would haue bin very chargeable. By means wherof we contented our selues with this one way here set down, not douting, but that euery one with small paines may attain to the making of all kinds of Dials in this book expressed. As for a great part of them, euery Artificer may easily vnderstand.

Onely thus much I aduertiſe the vnlearned, that they muſt acquaint thēſelues with ſome few Mathematicall principles, as to know what the Eleuation of the Pole meaneth, how a ſquire line is to bee drawne, and ſuch like, which (if they want a teacher) they may ſufficiently learne by themſelues out of *Records Caſtle*, his pathway and ground of Arts, publiſhed in the Engliſh tongue: for theſe tearmes could not be auoyded, neither plainly deſcribed without much tediouſneſſe.

We haue here added alſo examples and figures to euery kinde, that ſo the precepts might appeare more plaine and eaſie: ſo that there is no plaine plat or wall, howſoeuer it ſtandeth, or be placed either Declining, Reclining, or Inclining, but by the helpe of this booke you may draw a Diall vpon it.

If any man complaine of obſcurity, he muſt know, that *Difficilia quæ pulchra*, and yet ſmall paines ouercommeth all.

The making of the Horologicall Cylindre, and the Ring, with ſome other Inſtruments, we haue preſently omitted, partly for their curioſity in cutting and delineation, and partly becauſe (if occaſion ſerue) we will entreate of theſe kindes of Horologicall Inſtruments by themſelues, together with the making of all kindes of plaine Dials in this booke, preſcribed by the way of Geometricall proportion.

In the meane while (gentle Reader) committing
this booke to thy fauourable acceptation,
and thy ſelfe to the protection of
the Almighty, I end.

THO. FALE.

To my louing kinſman Tho. Osborne.

THis booke, which ſeuen yeeres ſince, was in a manner perfected (as you know) doth now vpõ iuſt occaſion preſent it ſelfe to the view of the world: wherein you haue taken ſuch paines for the triall of each example, that I thinke none can finde any great fault, but ſuch as can ſee farre into other mens faults, and forget their owne. For after we found ſome precepts in Witekindus to be falſe, we were enforced to trie and examine with great care each figure and example in the Sunne. And therefore if any receiue beneſit by this our triall, I would you ſhould haue your due praiſe you deſerue.

I haue altered ſome few things, and added the making of the South & North Erect Declining Dials, by the way of Geometricall proportion: becauſe thoſe kindes be moſt in vſe, and I would the learner ſhould haue his choiſe of the eaſieſt way.

The grauer of the Figures was one M. Iod. Hondius, who hath ſhewed himſelfe an excellent workman in the great Globes ſet forth by M. Mullineux, and the Maps of England for M. Camdens booke: and whether he hath performed like diligence in theſe, I referre it to your ſelfe to iudge. If any be deſirous to haue the Inſtrument mentioned in the beginning of this booke, for the tryall of plats, I hope you will helpe them to it: for being of your owne inuention, I know none ſo fit as your ſelfe to make it: on which Inſtrument alſo, it were conuenient to draw the quadrant Horologicall, that ſo it might ſerue for diuers vſes.

I truſt you will not be offended, in that I leaue vnder our names this ſmal monument vnto the world, as a ſpeaking witneſſe of our thankefull hearts to this our Country, and a teſtimony of our affection toward the Arts Mathematicall. Thus beſeeching the Lord (who hath endued you with extraordinary knowledge in all Manuall Sciences) to finiſh that good worke of his heauenly grace already begun in you, to his glory and your owne comfort, I take my leaue. Commend me many times to your ſelfe, and all our good friends. From London, Ianuary 3. 1593.

Yours aſſuredly, T. F.

Aduertisements to the Reader.

NOte alwaies, that in euery Diall the one end of the Stile must bee placed directly towards the North Pole, and the other end towards the South Pole: for about these two starres the whole heauens are moued, they remaining immoueable. The North Pole is a starre in the North part of the heauen, being raised aboue the earth or our Horizon 52.d. And this changeth his height, if you go Northward or Southward one degree in 60. miles: but Eastward or Westward it altereth not. The Eleuation of the Pole is the height of this starre aboue the earth.

Obserue also, that the Substile is the line or place ouer which the Stile or Gnomon in your Diall directly hangeth. The space betweene the Stile & Substile is the iust height thereof.

One line cutteth another squire-wise, when they make right and equall angles.

The Contingent or touch line, is that which is drawne by any point of another line or circle, so that it toucheth the same: and this line commonly in all Dials is drawne squire-wise to the Substile.

A quadrant is the fourth part of a circle.

The Meridian and twelue a clocke line are all one.

I call these lines parallel, which are euery where of like distance one from another: example whereof you may see in the East & West diall, where all the houre lines be parallell.

You may make all kinds of plaine Dials vpon one stone, if you prepare it first to be square like a Dye, and then take off the eight corners, and all the sharp sides, so shall you haue 25 plaine plats besides the base, or foote whereon your Diall must stand.

If any be desirous to haue this Instrument ready made, let him enquire at the Printers, and he shall heare of them.

THE

The making of an Instrument to *finde out the situation of any plat or Diall, and to place them al-* ready prepared.

Chap. 1.

FOrasmuch as it is necessary before you can draw any Dial, to know how your plat is already or ought afterward to be placed, it shall bee expedient to shew the making & vse of an Instrument, wherby you may examine and try all plain plats, and place all dials being ready made and prepared.

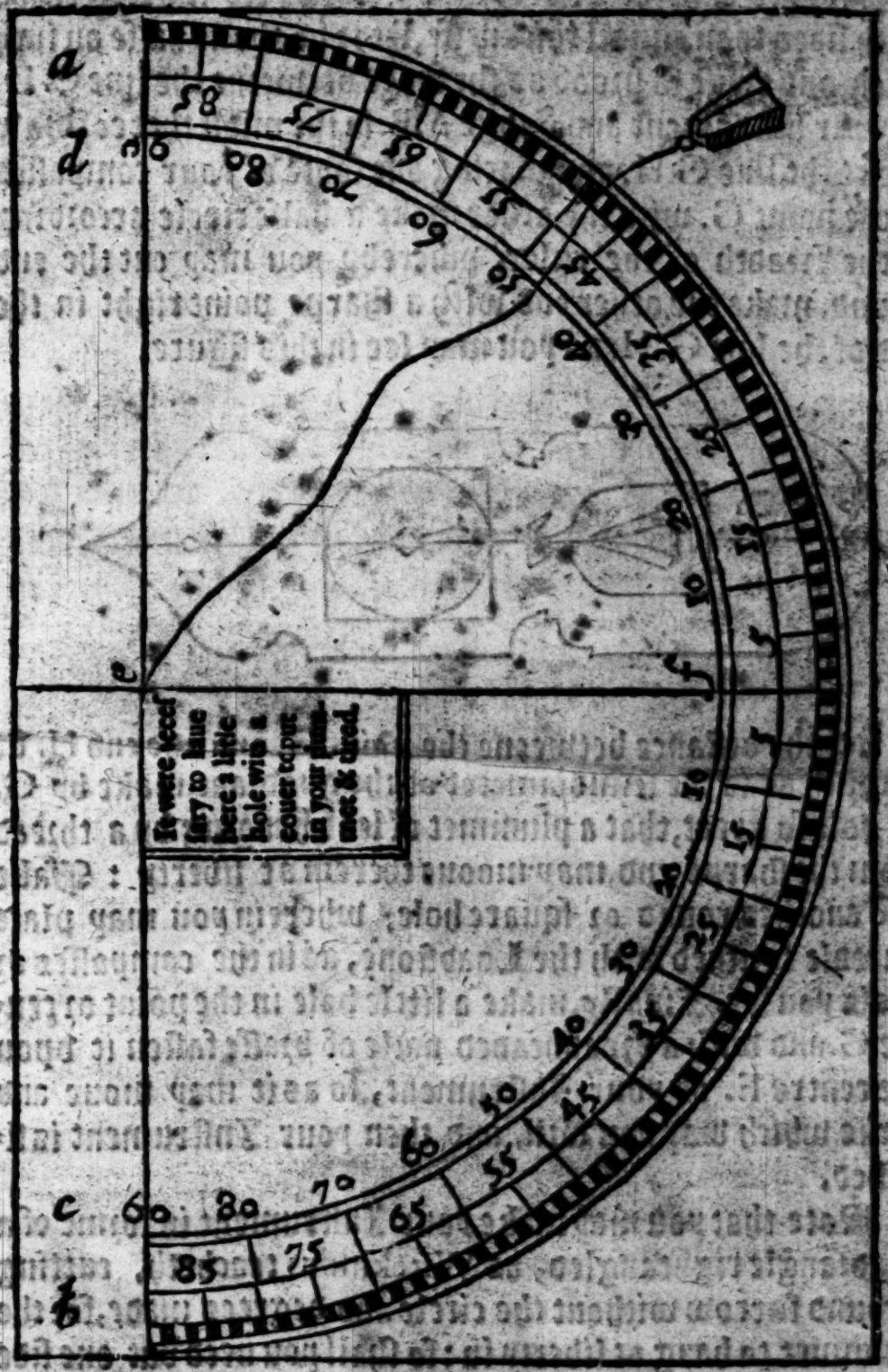
Prouide therefore an halfe circle of Pearetree, Walnuttree, Box, or any other close grained and solid wood, being well seasoned, so that the alteration of the weather at any time may not make it change from the first proportion thereof. Let it be perfectly tryed on both sides of an euen thicknesse, halfe or three quarters of an inch thick or more if you will, and sixe or eight inches broad as you thinke good. The edge or side A. B. must be very right. Then draw the Line C. D. three quarters of an inch equally distant from the side A. B. place one foote of your compasses in the centre E. which is the midst of the line C. D. and with the other draw halfe a circle from C. to A. deuide it into two equall parts or quadrants,

drants, and laying your ruler vpon the centre E. and vpon this diuision drawe the line E. F. this done, deuide each of these quadrants into 90. equall degrees of parts, which you may thus doe: First, diuide each of them into 3. equall parts, and euery of these into three other parts, so shall you haue 9. diuisions in either quadrant, whereof euery one shall represent ten degrees. Againe, part euery one of these into 2. and each of those into fiue (if you can) and so is each quadrant diuided into 90. degrees.

Moreouer, it were necessary if your Instrument were large inough, to part each degree into 60. minutes, or at the least into 3. whereof each part may containe 20. minutes. This done, fasten a thread well waxed, in the centre E. with a plummet of lead on the end, so that it may moue at free liberty.

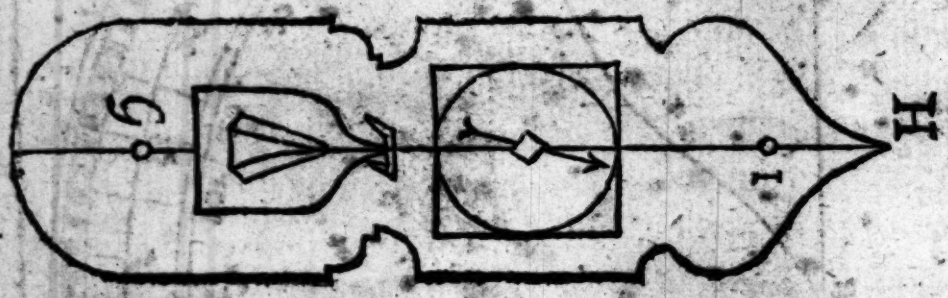
You may also (if you will) vpon this side of the quadrant between E. D. drawe the diall, whose delineation is taught in the 28. Chapter.

The



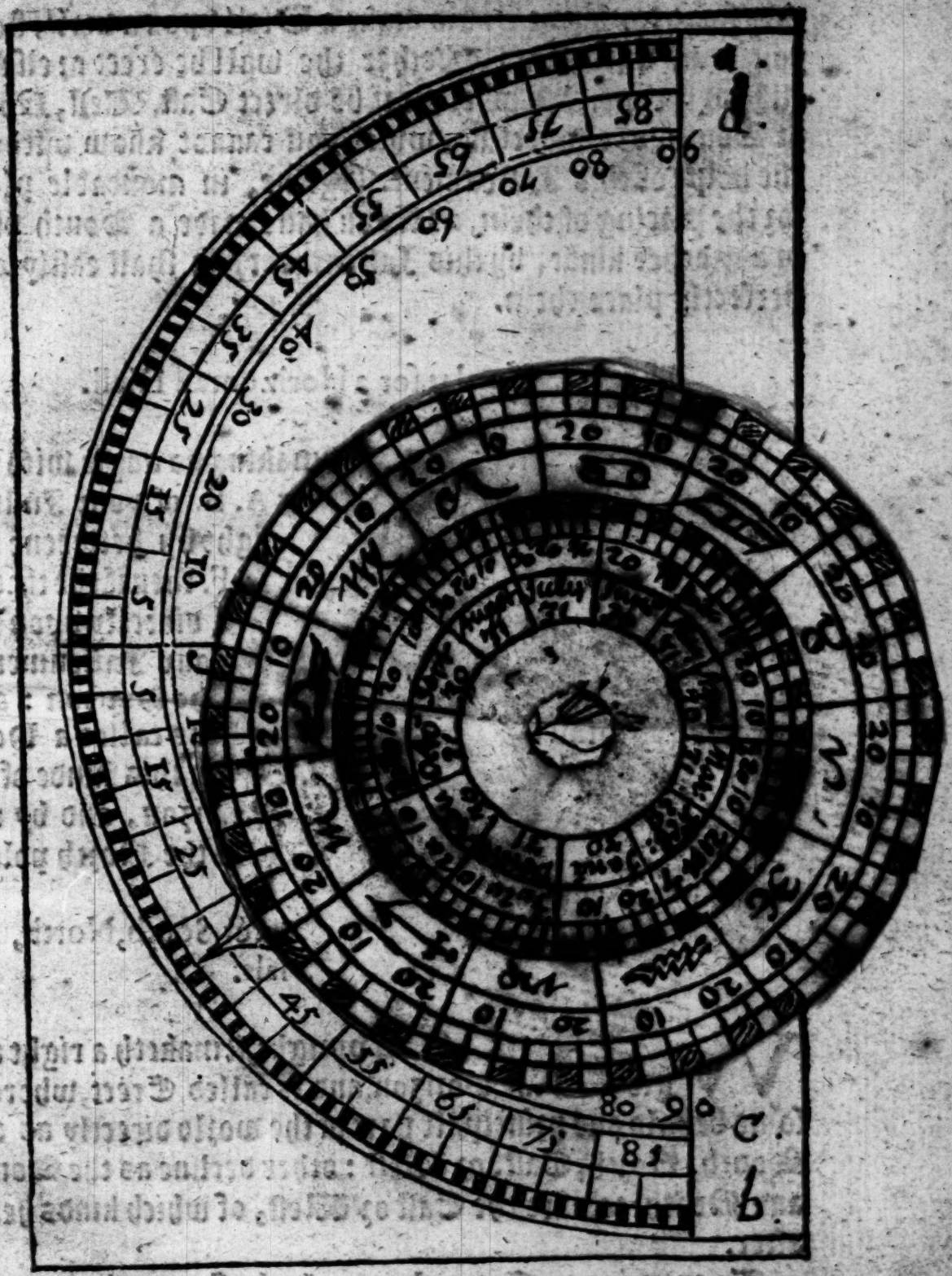
The former side of your Instrument thus finished, let the other be altogether like vnto it, except that in stead of the thread with the plummet, you must haue a plumbyule made in this manner.

Prepare a piece of very good wood, try it perfectly on both sides to an equall thickneſſe, let it be about halfe an inch thick, and twiſe ſo broad as the ſpace betweene the line C. D. of your inſtrument and ye edge A.B. in the midſt thereof draw the right line G.H. and placing one foote of your compaſſes in the point G. with the other make a halfe circle according to the breadth of the ruler, whereby you may cut the end round, make the other end with a sharpe point right in the end of the line G.H. as you may ſee in this figure.



Let the diſtance betweene the point G. and the end H. be ſo much as is the ſemidiameter of the quadrant, make by G. an hole ſo great, that a plummet of lead hanging by a thread from the sharpe end, may moue therein at liberty: Make alſo another round or ſquare hole, wherein you may place a needle touched with the Loadſtone, as in the compaſſes or dyals you ſee. Finally, make a little hole in the point or centre G. and with a broadheaded naile of braſſe faſten it vpon the centre E. of your Inſtrument, ſo as it may moue and turne which way you will, and then your Inſtrument is finiſhed.

Note that you may make your Inſtrument in forme of a quadrangle rightangled, as Witekindus teacheth, cutting a round furrow without the circle and degrees made, for the plummet to hang at liberty in: ſo ſhall you need but one ſide of your inſtrument to vſe, with a compaſſe or needle touched with the Loadeſtone for the declinations. But the forme of the other, whoſe making we haue taught, ſeemeth more commodious, behold the Figure.



The vse of this Instrument. Chap. 2.

The vse of this instrument is in examining and placing the plat or diall. In immoueable plats, to know how

they stand, as if you would make a Diall vpon a wall, first, you must vnderstand whether the wall be erect or else reclining or incline: then whether it be direct East, West, North or South, or else decline, which you cannot know without the helpe of this Instrument. Againe, in moueable plats for the placing of them, as if you haue made a South diall or any other kinde, by this Instrument you shall easily and perfectly place them.

The triall of a plat for a Horizontall Diall.

IF your plat seeme to lye plain, making no angle with the Horizon, set the side or Diameter A. B. of your Instrument vpon it, and erect ꝧ plumbvle right vp betweene the two quadrants precisely ouer the line E. F. then if the thread with the plummet hanging at liberty fall directly vpon his line G. H. which way soeuer you turne your Instrument, such a plat is said to make no angle with the Horizon: and therefore the diall which is made vpon it, is called a Horizontall diall. In like manner may you place this kinde of diall being ready made parallell to the Horizon, and by the helpe of the needle direct the stile towards the North pole.

The trying of plats for Erect, Direct, South, North, East and West Dials.

WHen the plat standeth vpright, it maketh a right angle with the Horizon, and is called Erect, whereof some behold one principall part of the world directly as the South, North, East, or West: other decline as the South and North, toward the East or West, of which kinds hereafter.

To examine an Erect plat, apply the side or diameter A. B. of your Instrument vnto it, the thread with the plummet on the foreside hanging at liberty. If the thread fall vpon the line E. C. or E. D. the plat is Erect.

This

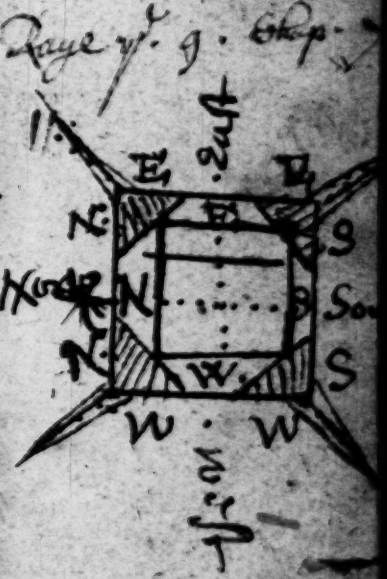
This done, apply the said line or diameter A.B. to the plat, your Instrument being placed equally distant to the Horizon, and the plumbrule upon the line E. I. then if the needle stand directly ouer his caracter, the end touched with the Loadstone being next to the plat, that plat is called a South Erect Direct.

In the North all the foresaid things are to be considered, except onely that the end of the needle touched with the loadstone is farthest from the plat.

These things knowne, you may easily find out the East and West Erect Direct, if either you haue a line drawne squirewise to the caracter of the needle, or else if you place the plumbrule ouer the line E.C. or E.D.

And heere note, that the East and West are not said to decline, because the declination is accounted from the south and North, to the direct East and West points.

The examining of plats for Declining Dials.



ALl such plats as behold not same principall part of the world directly, are called Declining. The quantity of their declination is found out thus.

Apply the diameter A.B. of your Instrument to the plat, remembring to hold it equally distant from the Horizon. Then moue the plumbrule vntill the needle standeth right ouer the caracter, and the point of the ruler, which toucheth the degrees in the limb, shall shew how many degrees and minutes it doth decline: either toward the East if the plumbrule lye in the quadrant C.E.F. or toward the west, if in the quadrant D.E.F.

The trying of such plats as recline.

IF the plat standeth not vpright, but maketh an obtuse or blunt angle with the Horizon, it is said to recline. The

degrees

degrees of the reclination are found out thus.

Apply the Diameter A.B. of your Instrument to the plat, the one end placed vpward, the other downward: then moue the plumrule (the thread with ỹ plummet hauing free course) vntill the thread hang precisely ouer the line G. H. then the poynt of the ruler shall shew the degrees of reclination.

Page ỹ 29 to 31.

How Inclining plats are tried.

BVt if the angle which the plat maketh with the Horizon be acute or sharpe, then it doth incline. The quantity of inclination is thus knowne.

Apply the Diameter A.B. of your instrument to the plat, the thread with the plummet of the former side hanging at liberty, and marke what degree and minute the thread shall cut, for so much is the inclination.

The manner of trying those plats which recline and decline, or incline and decline.

Page ỹ 19 to 29 ỹ

IF your plat shall both recline and decline, or incline and decline: First seeke out the reclination as hath been shewed, and then the declination as in Erect declining.

The making of a Horizontall, or plaine lying Sunne Diall.

CHAP. 3.

YOur plat being prepared smooth and plaine, draw vpon it two lines, as in the figure following, the one A. B. the other C. D. cutting themselues squirewise, that is, making right angles in the point E. vpon which make the quadrant of any circle from the line E. C. to the line E. A. or E. B. and write at C. the North, at D. the South, at A. the East, at B. the West. And the line C. A. which here is the quadrant being deuided into 90. degrees or parts, the elec-

tion

tion of the Pole shall be accounted in it (which in our example is 52.d. from C. to A. and at the end of this number draw a line from the centre E. which shall be E. F. representing the stile & axtree of the world. Then draw another line K. L. by C. or by some other point of the line D. C. squirewise, so long as you can, which shall be called the touch line, or line of Contingence. Then measuring with your cõpasses the least distance of the point O. and the line E. F. or the stile, the one foote placed in O. which is the point of interlection, and the other extended toward E. where it shall chance to diuide or bee placed in the line E. C. marke that point or centre with the letter G. and draw with your compasses a halfe circle vpon this centre for ẏ equinoctial circle, from H. by C. to I. whose diameter must be equally distant to the line L. K. Then deuide this halfe circle into 12. equall parts: this done, lay a ruler vpon the centre G. and vpon euery marke or diuision made in the halfe Equator, & where the ruler shall touch the line of contingence, there make markes or pricks, by which pricks draw lines from E. for the houres. E. C. is the 12. houre, E. B. the 6. in the morning, E. A. the 6. at euening, the rest you may see in the figure.

And whereas in Summer the 4. and 5. in the morning, and also the 7. and 8. at euening, shall be necessary in this kinde of Diall: prolong or draw the lines of 4. and 5. at euening, beyond the centre E. which shall shew the houres of 4. and 5. in the morning. And likewise the 7. and 8. in the morning, for the 7. and 8. at euening.

You may obserue an order both in these and in all other erect direct dials, by diuiding the one halfe of the Equator, drawing houre lines for the forenoone, and obseruing the same distance from the Meridian line, on the other side for the afternoone: for the line of the 11. houre in the forenoone, is of like distance from the Meridian, that the 1. is in the afternoone, and the 10. as 2. and so of the rest.

When you would draw or make the halfe houres, you must deuide euery part of the Equator into 2. equall parts, vsing the ruler and the line of contingence as you finde in the

drawing

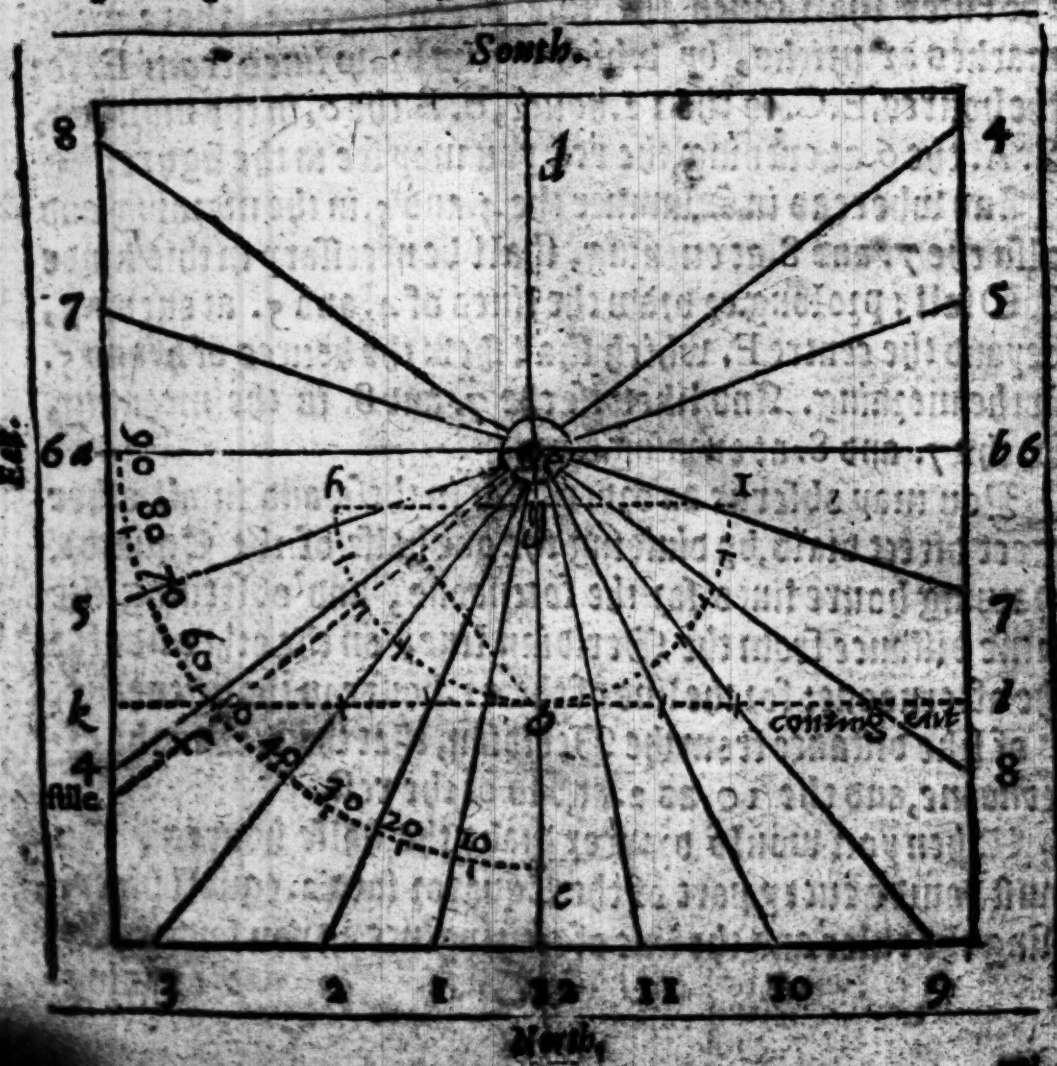
drawing of the houre lines.

And this remember for the drawing of the halfe houre-lines, not onely in this kinde, but also in all other kindes of dials, which afterward shall follow.

The Stile must be fixed in the centre E. hanging directly ouer the Meridian line E. C. with so great an angle, as the lines C. E. F. make, declining from that on neither sides.

The Equinoctiall circle, the Quadrant, the line of the Stile and of Contingence, must be lightly drawne, because they ought to be put out againe, in that they serue to no vse but for the drawing of the Diall. And this likewise remember in all other kindes of Dials, that the preparatiue or pricked lines must, after the making of the Diall, be omitted and extinguished, as altogether vnprofitable.

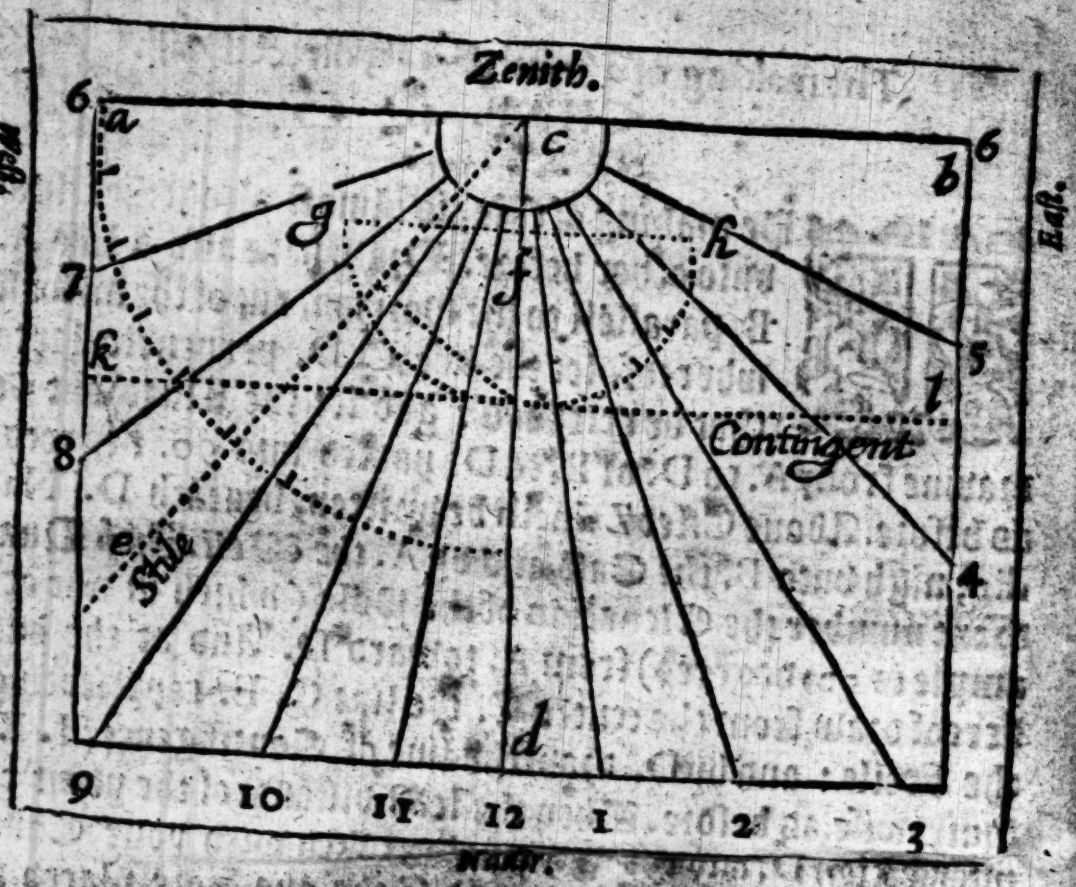
This and all other kindes of Dials may most fitly bee drawne vpon a cleane paper, and then with the helpe of your compasses placed on the plat.



The

The making of a South Erect, direct Diall. CHAP. 4.

The making of this, is almost altogether like vnto other before. Draw here also a line A. B. parallell to the Horizon, out of the middest whereof, let the line C. D. perpendicular to that be extended: and let the Quadrant be drawne from A. to D. or B. to D. parted into 90. degrees, as before. Aboue C. let Zeineth be written, beneath D. Nadir; nigh vnto B. the East, and by A. the West. In y Quadrant number the Elevation of the Pole (which in our example is 52. degrees) from A. toward D. And at the end hereof draw from the centre C. the line C. E. representing the Stile: and by D. draw the line of Contingence, I. K. squirewise, as before. Then the least distance of the point or intersection D. and the Stile being taken with your Compasses, extend them in the line D. C. the one foote placed in D. set the other in F. toward C. and draw by F. the Diameter of the halfe circle of the Equator equally distant to the line K. L. which must be made vpon the centre F. from G. by D. to H, and diuide it into 12. equall parts, vpon euery one of which and the centre F. the ruler being placed, whersoeuer it shall happen to touch the line of contingence, there make markes. Then from the centre C. by these markes the houre line must be drawne. The line C. A. shall shew the 6. in the morning, C. B. the 6. at euening, C. D. the 12. &c. The Stile must be placed or fixed in the centre C. hanging precisely ouer the line of the 12. houre, with so great a distance, as the angle D. C. E. is. This kinde of Diall doth receiue and shew onely but 12. houres at the most.



The making of a North Erect, Direct Diall.

CHAP. 5.

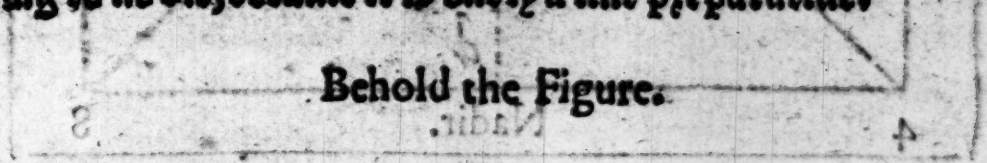
HEre as in the South make a line Parallell to the Horizon, A. B. put it squirewise with the Perpendicular C. D. let C. bee the centre. At C. write Zenith, at D. Nadir, &c. From C. draw the Quadrant of a circle to D. or B. deuide this into 90. Degrees, account the Elevation of the Pole (which in our example is 52. d.) from A. toward C. Draw at the end of this number the line E. F. for the Stile. Afterward draw the line of Contingence by C. squire-wise, and take the shortest distance, with your compasses betweene the poynt C. and the Stile, placing the one foote in the poine

C.

C. extend the other toward E. in the line C.D: making a point or pricke G: whereupon (as a centre) the same wideneſſe of the compaſſes remaining, deſcribe the halfe Equator by C. ended with the Diameter H. I. equidiſtant to the line of the Contingence. When you haue diuided this halfe circle of the Equator into twelue equall parts, lay the ruler vpon the centre G. and vpon each diuiſion of the Equator, and where it ſhall touch the Contingent line, make markes. This done, draw the lines for the houres, by thoſe markes from the centre E. but thoſe very few, that is, two nigh vnto A: and two by B. but prolong and extend them beyond the centre E. ſo that their contraries may be made: for in this kinde of Dials there be but onely ten houres profitable, that is, 4, 5, 6, 7, 8, before noone, and 4, 5, 6, 7, 8, after noone; which ſhew but onely in Summer, from the entring of the Sunne into ♈, vntill ſuch time as it entreth ♎.

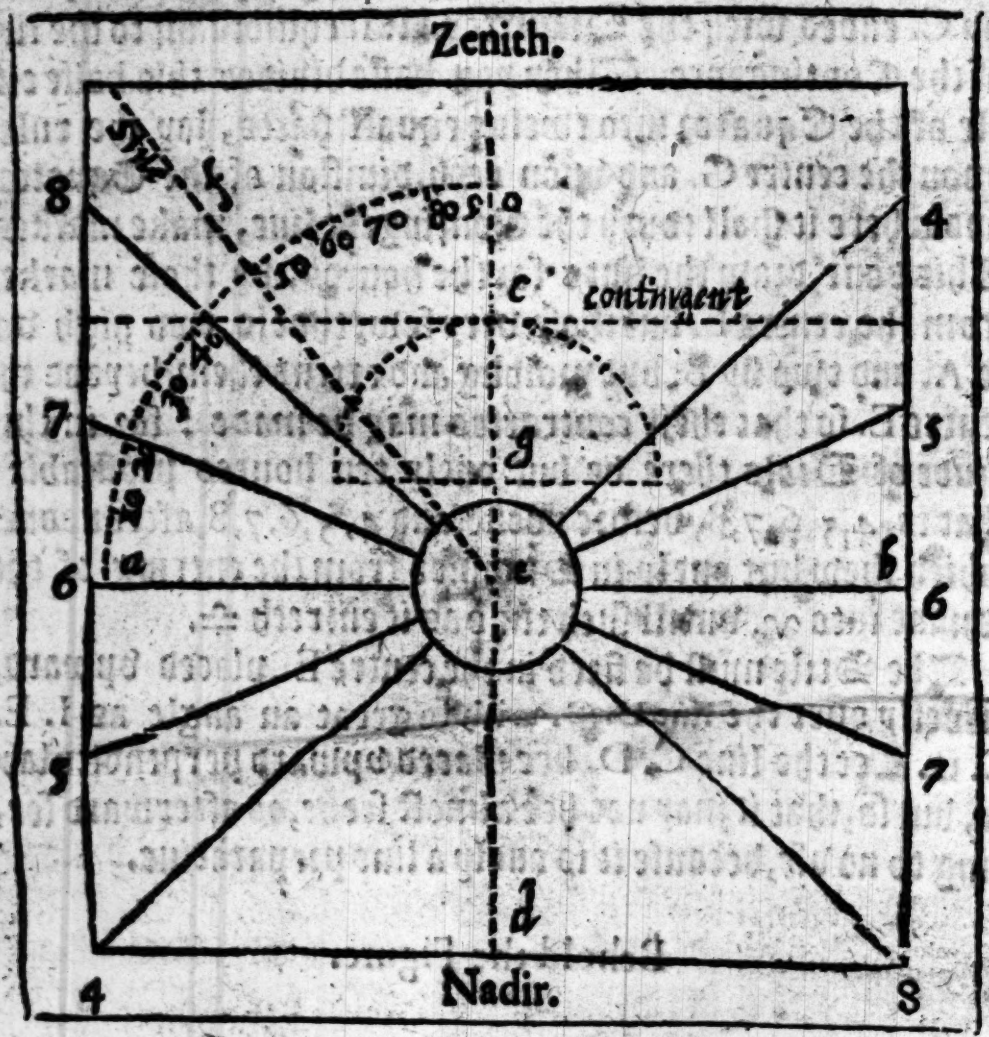
The Stile muſt be fixed in the centre E. placed vpward, directly ouer the line E. C. with ſo great an angle as I. E. C. is. Let the line C. D. bee placed vpward perpendicularly, but ſo, that it may not bee almoſt ſeene, as afterward ſeruing to no vſe, becauſe it is onely a line preparatine.

Behold the Figure.





A North Diall erect, direct.



The making of the East and West Erect Dials.

Chap. 6.

If you know the making of one of these, you may easily make them both, for they be very like, differing onely in the naming of the houres, for the one containeth houres for the forenoone, and the other for the afternoone.

You must therefore on your plat make the quadrant of a circle A. B. C. which may afterward easily bee put out, as

all

all the other lines must be, except the houre lines: let the A. B. be Perpendicular: B. C. Parallel to the Horizon, and let the arke behold the South, which being deuided into 90. degrees, number therin the eleuation of the Pole downward from A. toward C. by the end of this number, and by the Centre B, draw a line so long as your plat will giue you leaue, whose South end shall behold precisely the Equinoctiall circle. At which end draw a circle, whose diameter shall be almost the third part of the line. Then draw another Diameter or line in the centre, squirewise to the other, which shall shew the axtree of the world, and be the line for the 6. houre. Afterward at the outward sides of the circle, draw two contingent lines, one beneath, the other aboue, so that they may be Parallell to the middle line. Deuide each quarter of the circle in fiue equall parts. Then place the ruler vpon the centre, and each of those markes or parts, and where it toucheth the lines of contingence, there make marks in them. Afterward draw a line by those two markes which be next to the 6. houre, in the lines of contingence, which may be equally distant from the line of the 6. houre.

In like manner doe with the rest; so that you may haue in the East Diall, two aboue the 6. houre, the 4. and 5. in the morning, and vnder it 7, 8, 9, 10, 11. In the West Diall likewise 7. and 8. in the euening aboue the 6. houre, and vnder it 6, 5, 4, 3, 2, 1. Neither of them doe shew the 12. houre, because at that time the Sunne beames be parallell to the plat.

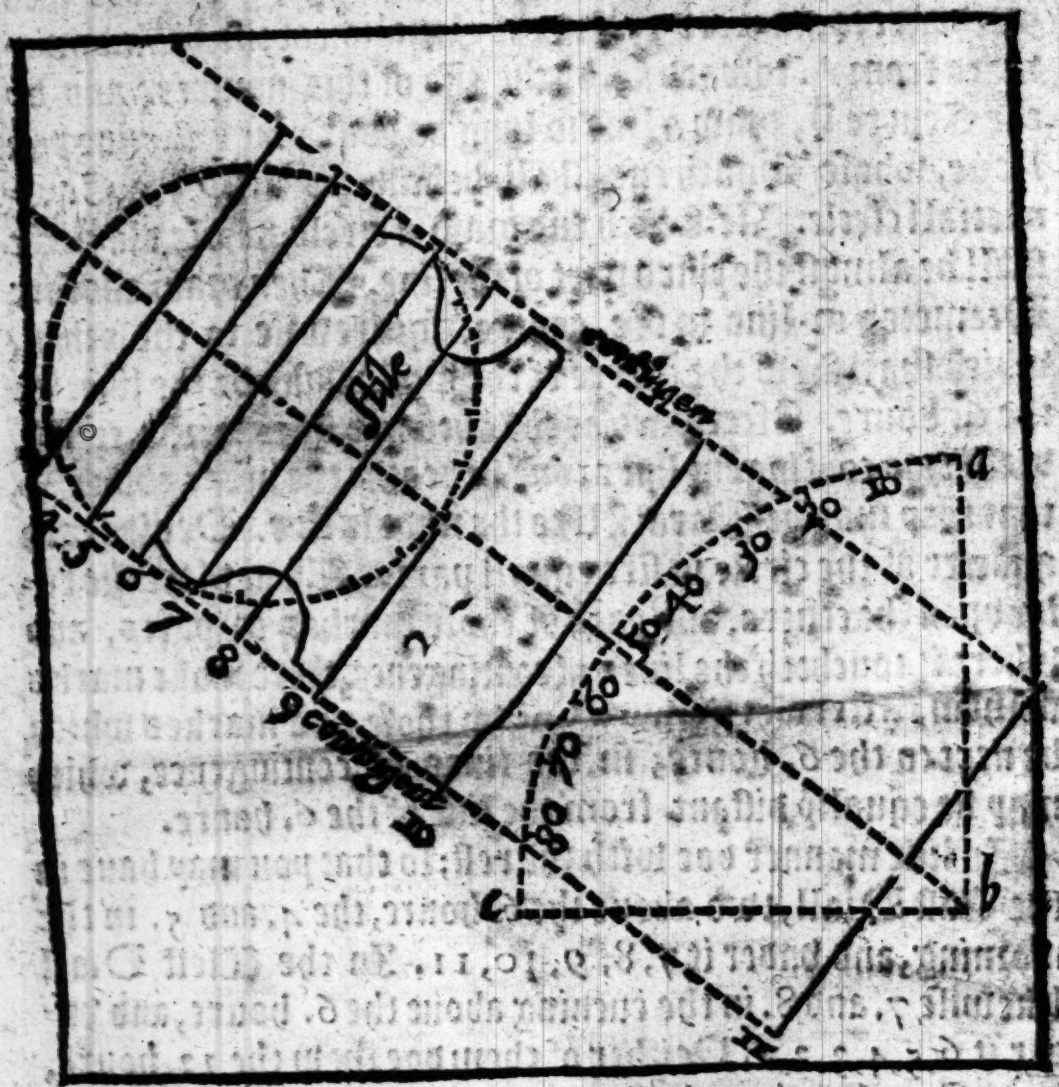
Fixe the Stile in the centre of the circle right vp from the Plat, so long as the Semidiameter of the circle is onely shewing the houre with the very top or end thereof. Yet it were more conuenient to haue it placed along ouer the line of the 6. houre, being a plate of yron or some other metall, being so broad as the Semidiameter of the circle is.

Behold the figures following.

The

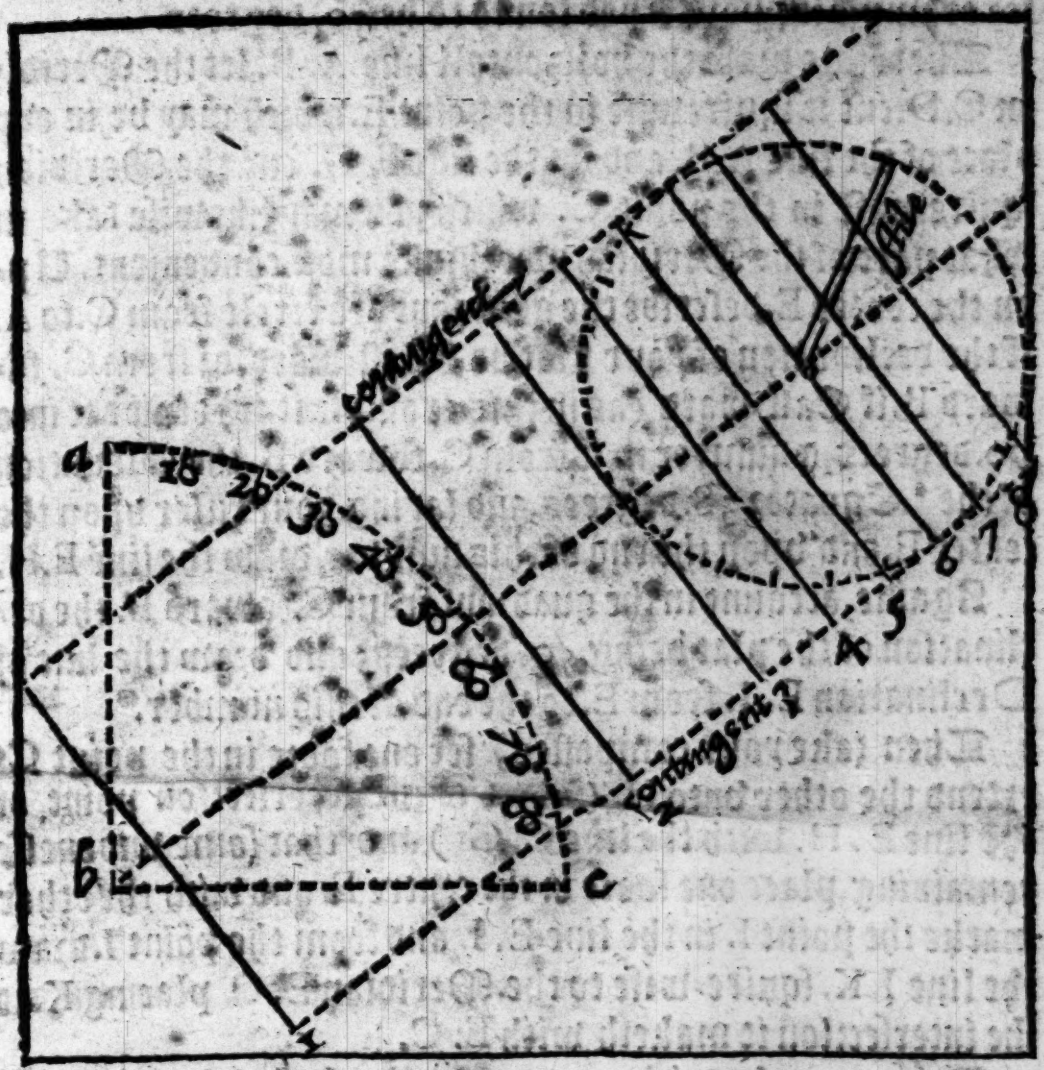
The Art of Dialling.

The East diall Erect.



The

The West Diall erect.



Note that these fiue kinds of Dials before taught may be made vpon a stone cut square in the forme of a die.

The making of a South Erect declining Diall, which may be placed on any vpright wall whatsoeuer. CHAP. 7.

IN all Declining Dials because the Stile doth not hang directly ouer the meridian line, therefore you must first finde out and place the Substile (which is the line ouer which the Stile directly hangeth) and likewise the line of the Stile: which may be both easily and speedily performed in this manner.

First, by your instrument seeke out the Declination of

the wall or plat, whereupon you would make a diall, which for example suppose I had found to be 50. degrees.

Therefore draw the horizontall line A. B. let the Meridian C.D. cut it squirewise in the point E. which may be in any place of the line A.B. and let the line F. G. cut the Meridian squire-wise in the point C. which you may likewise take in what part of the Meridian you thinke most conuenient. Upon the center E. describe the quadrant of a circle from C. to A. if the declination of your plat be West-ward, or from C. toward B. if East-ward (as in this example it is) diuide it into 90. degrees, & number in it from C. toward B. the Eleuation of the * Equator 38. degrees, and laying your ruler vpon the center E. and vpon the end of this number, draw the line E.H.

* This is alwaies so much as the Eleuation of the Pole wanteth of 90. degrees. as in example, The eleuation of the Pole is 52 degrees which taken out of 90 degrees the Equator number 38 degrees.

90 degrees.
52 degrees
38 degrees.

with 38 degrees is euen the complement of 52 deg.

Againe, account in the quadrant from C. toward B. the declination of the plat being 50. degrees, and draw the line of Declination E. I. from E. to the end of this number.

Then take your compasses, set one foote in the point C. extend the other vnto H. (which is the intersection point of the line E. H. with the line C. G.) and that same wideneſſe remaining, place one foote in the centre E. and with the other marke the point I. in the line E. I. and from the point I. draw the line I. K. squire-wise to the Meridian E. C. placing K. at the intersection it maketh with E. C.

Moreouer take with your compasses the iust length of the line I. K. and placing one foote in C. turne the other toward F. and make the point L. in the line C. F. draw the Substile from E. by L. Let the line of Contingence be drawne squire-wise to the Substile in the point L. Substil.

This done, take the distance betweene the centre E. and the point K. and place it in this line of Contingence from the point L. vnto M. and make the point M. that the line E. M. may be made from E. vnto M. for the stile. Stile.

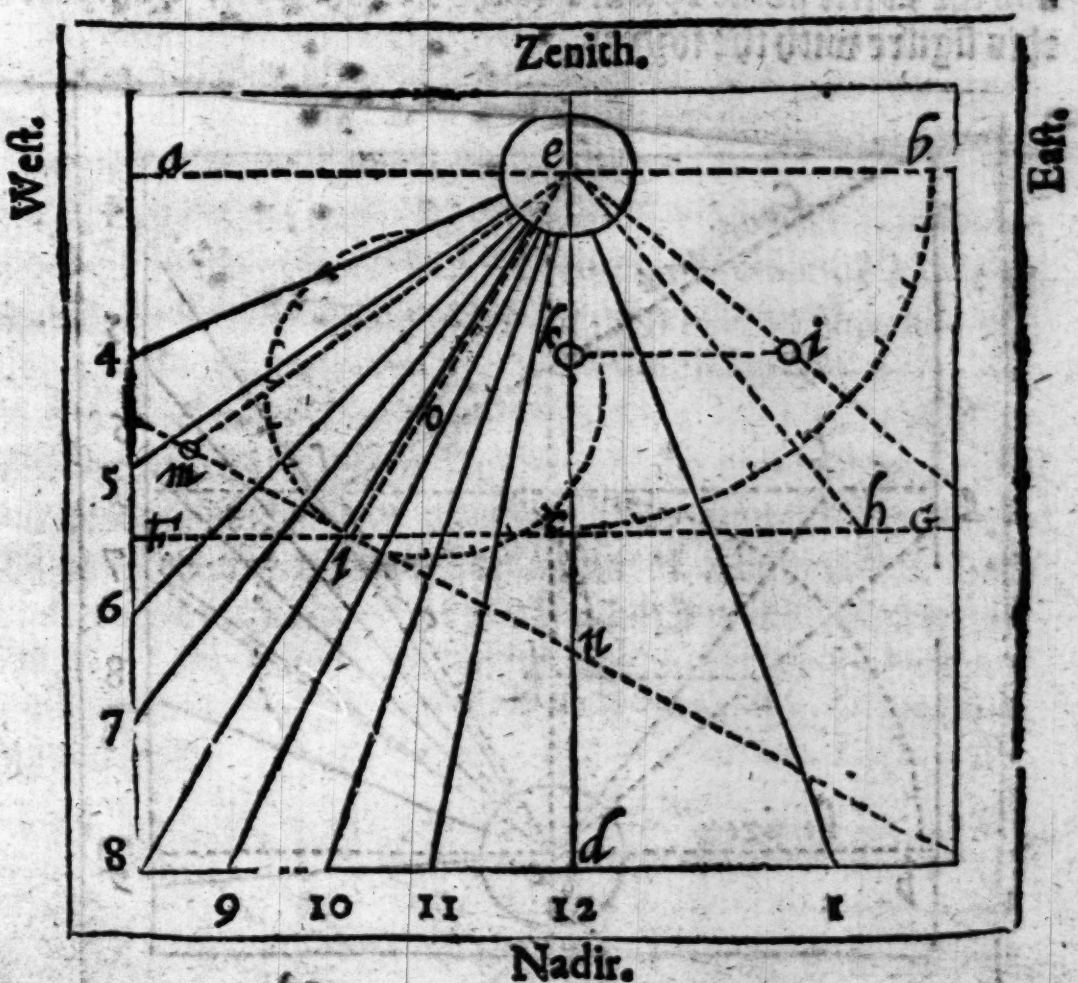
Measure with your compasses the least distance betweene the point L. and the Stile, and with the same wideneſſe, one foote remaining in L. turne the other toward E. and make the centre O. in the Substile: vpon which describe the Equi-

noctiall

noctiall circle. Then placing your ruler vpon O. being the centre of the Equinoctiall circle, and N. (which is the point of the interſection of the Meridian and Contingent) marking where it cutteth the circumference: for there you muſt begin to diuide it into 24. equall parts, notwithſtanding thoſe 12. are onely in vſe which are next the contingent.

Finally, place your ruler vpon the centre O. and vpon the ſeuerall diuiſion points of the Equator, and where it toucheth the line of Contingence, make markes, by which from the center E. draw the houre lines.

Place the Meridian perpendicularly vpon the wall, the centre E. vpward, the Stile pointing downeward. Let the Stile hang directly ouer the Subſtile making an angle equall to E. M. L.

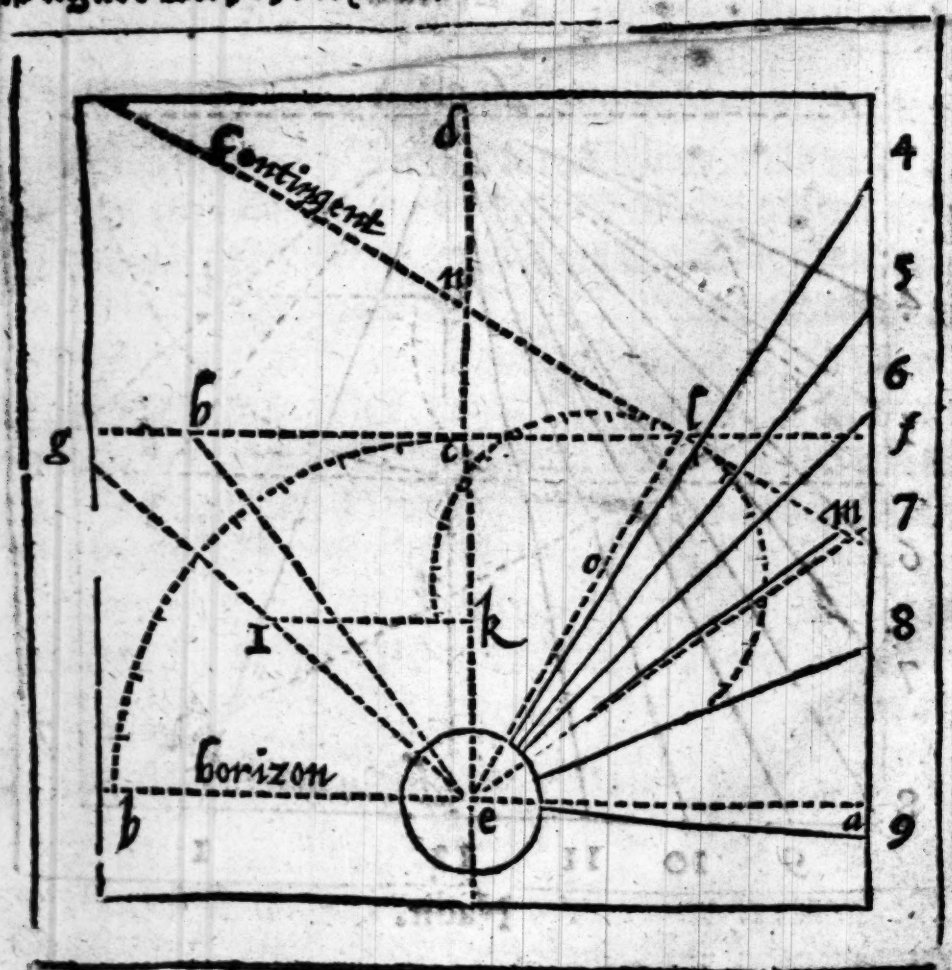


The making of a North Erect Declining Diall. CHAP.

THe North Erect declining Diall differeth from the South onely herein, that the centre is to be placed downward, the Stile pointing vpward tothe North Pole, and that the Meridian repreſenteth the 12. houre at midnight and at noone. Therefore if the declination be toward the Eaſt, you muſt account the houre lines from that which is as it were the Meridian ſouthward, 1, 2, 3, 4, 5, 6, &c.

But if it decline toward the Weſt, number them backeward, 11, 10, 9, 8, &c. omitting the firſt 3. which are before Sunne riſing and after Sunne ſetting in our elevation.

Let the line E. D. be placed perpendicularly vpon the plat, and the Stile point vpward to the North Pole. Compare this figure with the former.



Another

Another way to make the South Erect Declining Diall.

Chap. 9.

ALbeit wee haue plainely and perfectly shewed the making of the South and North erect Declining Dials, in the two former Chapters; yet to satisfie them that delight in variety; here is also declared another way, whereby you may make them, namely, by the helpe of Arithmeticke, and the Table of Sines which is placed in the end of this booke for this intent. Reade the vse of the Table of Sines. pag. 60.

Therefore the Eleuation of the Pole being knowne, and the Declination of your plat, by your Instrument found out:

Multiply the Sine of the complement of the Eleuation, by the Sine of the complement of the Declination, diuide the product by the whole Sine (which is 100000) and you shall haue a quotient Sine, whose arke is the distance of the Stile from the Substile, which distance keepe.

Then take the complement of this distance, and the Eleuation of the Pole, and multiply the Sine of the lesser by the whole Sine, parting the product by the Sine of the greater: the quotient Sine which shall come of this diuision, shall giue you an Arke, whose complement is the distance of the line of the Substile from the Meridian, which distance you shall likewise keepe. For better instruction herein, consider the example.

Example of a South Diall declining 45. d. Eleuation of the Pole. 52. d.

90
52
38. d.

FIrst, I enter the Table of Sines, for the Sine of the complement of the Eleuation, which is 38. d. and I finde it

it to be 61566. Then I looke for the Sine of the complement of the Declination, which is 45. d. and I find that to bee 70710. This done, I multiply the one by the other, and the product is 4353331860. which I diuide by the whole Sine being 100000. whereof commeth a quotient 43533. With this quotient Sine I enter the Table, and because I finde not the iust number, I take that which is next either greater or lesse vnto it: (which you must alwaies remember to doe) for so small a difference maketh no alteration, and therefore I take in stead thereof 43523. whose Arke is 25. d. 48. m. which is the distance of the Stile from the Substile.

Then I take the complement of this distance, which is 64. d. 12. m. whose Sine is 90031. and the Eleuation of the Pole 52. d. whose Sine is 78801. and multiplying the Sine of the lesser, (which is the Eleuation of the Pole) by the whole, 100000. the product is 7880100000. which I diuide by the Sine of the greater, to wit, the Sine of the complement of the distance of the Stile from the Substile, whose Sine is 90031, whereof commeth this quotient 87526 whose Arke is 61. d. 5. m. The complement of which Arke is 28. d. 55. m. being the distance of the Substile from the Meridian. These distances being thus found out, the drawing of the Diall followeth.

First, draw a line Parallele to the Horizon A. B. out of whose middle point C. draw the Meridian line squire-wise C. D. vpon the centre C. make the quadrant of a circle betweene A. and D. Here vnderstand that generally in all kindes of declining Dials, if the declination be towards the East, you must draw the quadrant towards the West, (except in the South reclining declining, and the North inclining Declining, where the contrary is prescribed) But if the declination be Westward, the quadrant must be drawne Eastward. Hereby you shall easily know on which side you ought alwaies to draw the quadrant, and which way the figures following doe decline. Your quadrant being made, diuide it into 90. degrees: number therein from D.

the

the distance of the Substile from the Meridian, which is 28.d.55.m. Draw at the end of this number the line C. E. for the Substile. Then from E. towards A. account the distance of the Stile from the Substile, which is 25.d.48.m. and at the end hereof, draw the line C. F. for the Stile. Afterward by the point E. or in any place of the Substile draw the Contingent line G. H. so long as you can squirewise to the Substile. Then take with your compasses the least distance betweene E. and the Stile, the one foote remaining in E. and the other extended in the Substile toward C. place at the pricke there made with the compasses, I. upon which pricke as a centre, the same wideneſſe of your compasses remaining, draw a circle by E. which shall represent the equinoctiall or Equator. Then lay the ruler upon the point I. and the intersection (whose marke is K.) of the line of Contingence, and the line C.D. (which is alwaies drawne so that it may cut the other) and where the ruler so placed shall touch the circle, there make a marke, and there begin to diuide it into 24. equall parts: notwithstanding those 12. onely are to bee vsed, which doe behold the contingent line. Then lay the ruler upon the centre I. and the Contingent line by euery diuision of the Equator, and where it shall touch the line of Contingence, there make markes, by the which from the centre C. draw lines for the houres, so many as shall be necessary.

The line C.D. shall alwaies shew the 12. houre, which must hang perpendicularly. Number the residue of the lines in their place, as they follow in order.

The line A.B. in such as doe decline is vnprofitable, except it so chance that some houre line falleth in it.

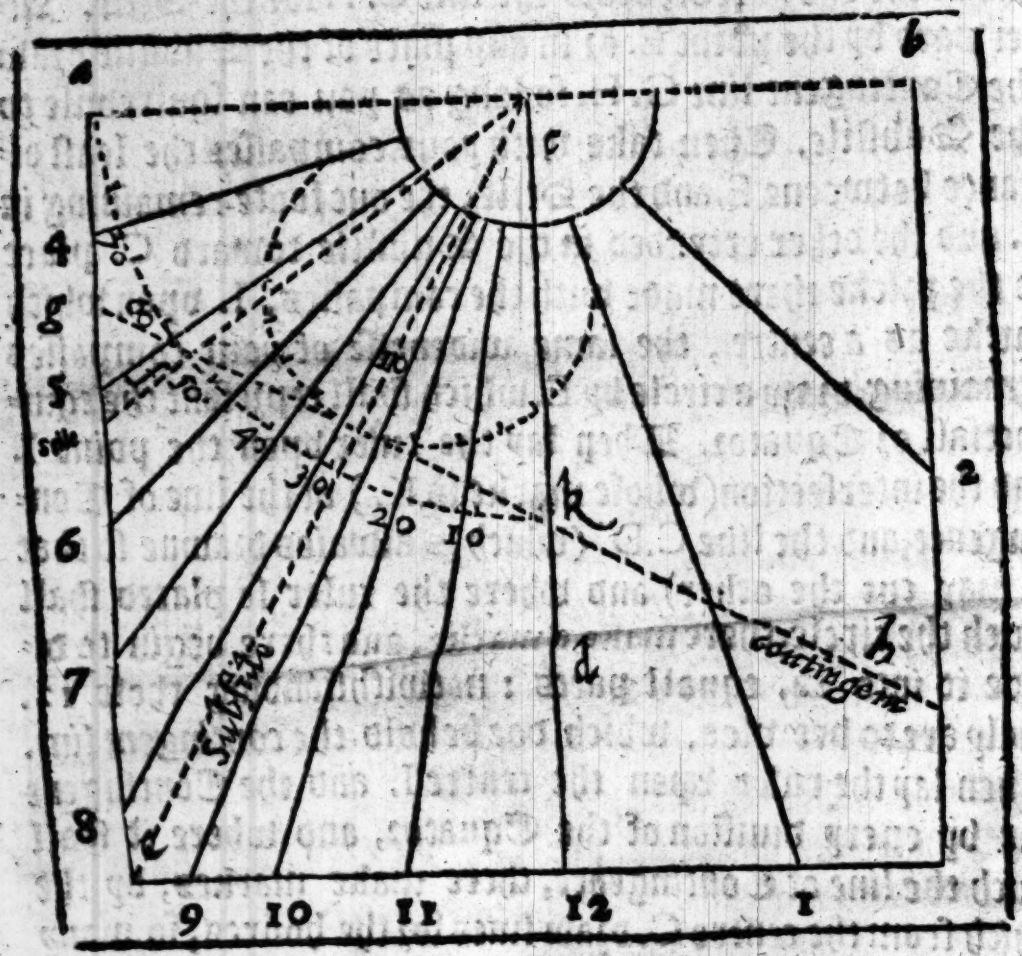
Let the Stile be fixed in C. hanging directly ouer the Substile, with so great an angle, as E. C. F. is, declining on neither side.

Note diligently the making of this declining Diall, because in those which follow, we meane not to repeate those things which heere haue been taught. And this one kinde

well

well knowne, all the other will seeme most easie. For better understanding hereof, behold the figure.

A South Erect declinig Diall.



The making of a North Erect declining Diall another way.

Chap. 10.

The distance of the Stile from the Subtile, and of the Subtile from the Meridian, is found out altogether like to the South Erect declining. Therefore you may resort thither for the working hereof, I will onely draw the Figure.

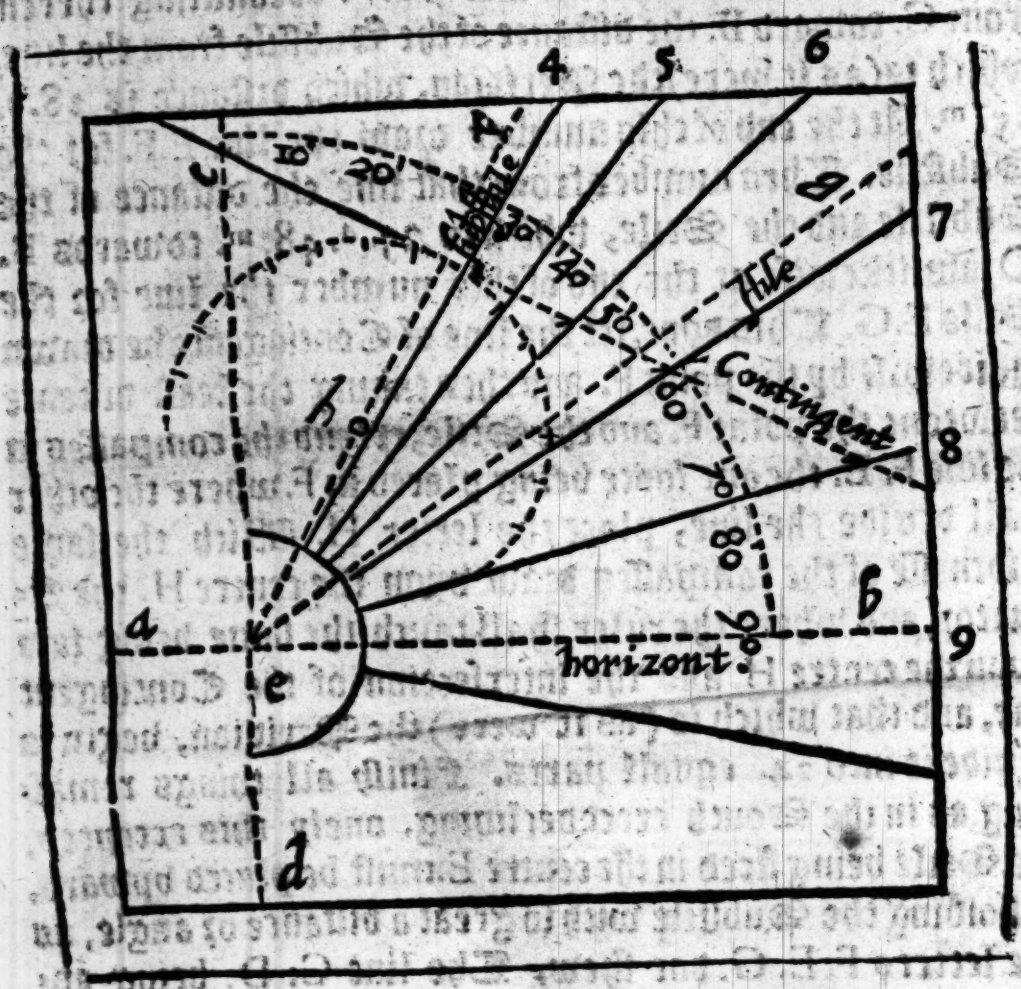
Let

Let the line A. B. being parallell to the Horizon, cut C. D. squirewise, placing E. at the intersection. Draw the quadrant from C. to B. deuide it into 90. d. accounting therein from C. toward B. the distance of the Subtile from the line, which is (as it were) the Meridian, which distance is 28. d. 55. m. At the end of this number draw the line E.F. for the Subtile. Then number from that line the distance of the Subtile and the Stile, which is 25. d. 48. m. towards B. Draw likewise at the end of this number the line for the Stile E.G. This done, let the line of Contingence be drawn squirewise by the point F. and then taking the least distance betweene the point F. and the Stile, extend the compasses in the line F. E. the one foote being placed in F. where the other shall deuide the line, place the letter H. With the same wideneſſe of the compasses draw vpon the centre H. the Equator, and where the ruler shall touch the same being laid vpon the centre H. and the intersection of the Contingent line, and that which is (as it were) the Meridian, begin to deuide it into 24. equall parts. Finish all things remaining, as in the South erect declining, onely this excepted, the Stile being fixed in the centre E. must be placed vpward, beholding the Subtile with so great a distance or angle, as the letters F. E. G. doe shew. The line C. D. being applyed to the plat perpendicularly, sheweth as it were the 12. houre at midnight: therefore account from that the houre lines, as they follow in order, 1, 2, 3. which houres haue no vse in this kinde of Diall for our Elevation, but from 4. &c.

Let the line A. B. be parallel to the Horizon, being lightly drawne, as the other preparatiue lines be, serving afterward to no vse.

Note, if the plat decline toward the East, as this figure doth, it is for the forenoone: and you must account the houre lines from that which is (as it were) the Meridian, forward 4, 5, 6, &c. If it decline toward the West, account them backward 11, 10, 9. as we shewed before.

A North erect declining Diall.



The making of a Meridionall or South Reclining direct Diall.

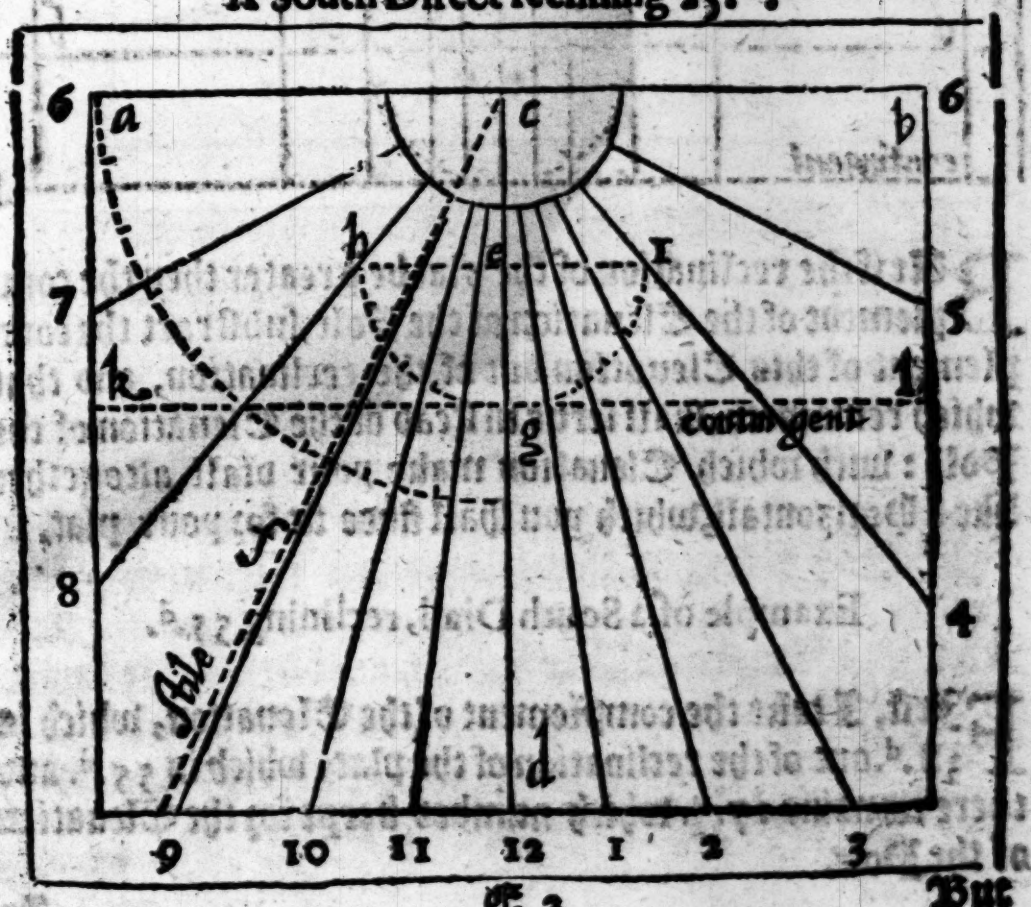
CHAP. II.

IF the Reclination of the plat bee lesse then the complement of the Elevation of the Pole, adde this complement, and the Reclination of the plat together, and with this number, as if it were the Elevation of the Pole, make a South erect direct diall, and it will be perfect and fit for your plat.

Example and delineation of a South Diall, reclining 25.d.

MAke the first line A.B. draw also another C.D. cutting the other with right angles. Then adde the Complement of the elevation of the Pole (which is 25.d. to the reclination of the plat (which is 38.d.) and the totall summe shall be 63.d. which number being in place of the Elevation of the Pole, account it in the Quadrant from A. towards D. and at the end hereof, draw the line F. for the Stile. Then make the line of Contingence K.L. squirewise to the line C.D. Afterward take the least distance with your compasses betweene the point G. and the Stile, with the wideneſſe, the one foote extended toward C. make a point or pick E. by which point draw the line H.I. equidistant from A.B. or K.L. upon E. make a halfe circle from H. by G. to I. which being divided into 12. parts, finish the rest as the South erect direct

A South Direct reclining 25.d.



But if the Reclination be equall to the complement of the Pole, make your Diall on this manner, like to the East and West.

Draw a line Parallell to the Horizon A.B. so long as the plat will giue you leaue, diuide it into 7. equall parts, and with the same wideues of the compalles, in the midst of the line, make a circle representing the Equator. Then draw two lines of Contingeue by the circumference of the circle, equidistant from the first A.B. Diuide the Equator into 24. equall parts. Finish the rest like the East or West diall: except in naming the houres, for that which is in them the 6. houre line, is here the 12. &c.

A South Direct reclining. 38.d.



But if the reclination of the plat be greater then the complement of the Eleuation of the Pole, substract the complement of this Eleuation out of the reclination, and that which remaineth, shall serue in stead of the Eleuation of the Pole: with which Eleuation make your diall altogether like a Horizontall, which you shall finde fit for your plat.

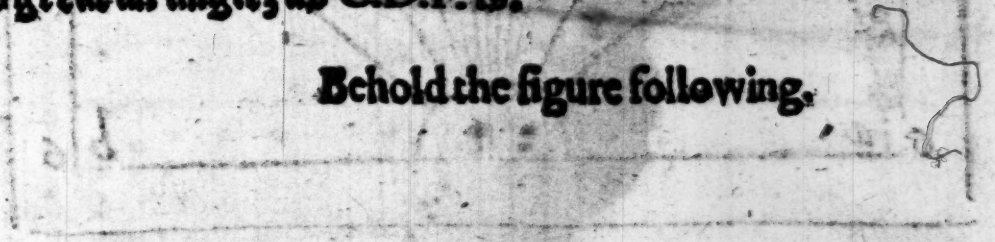
Example of a South Diall, reclining 55.d.

First, I take the complement of the Eleuation, which is 38.d. out of the reclination of the plat, which is 55.d. and there remaine 17.d. which number keepe for the Eleuation of the Pole.

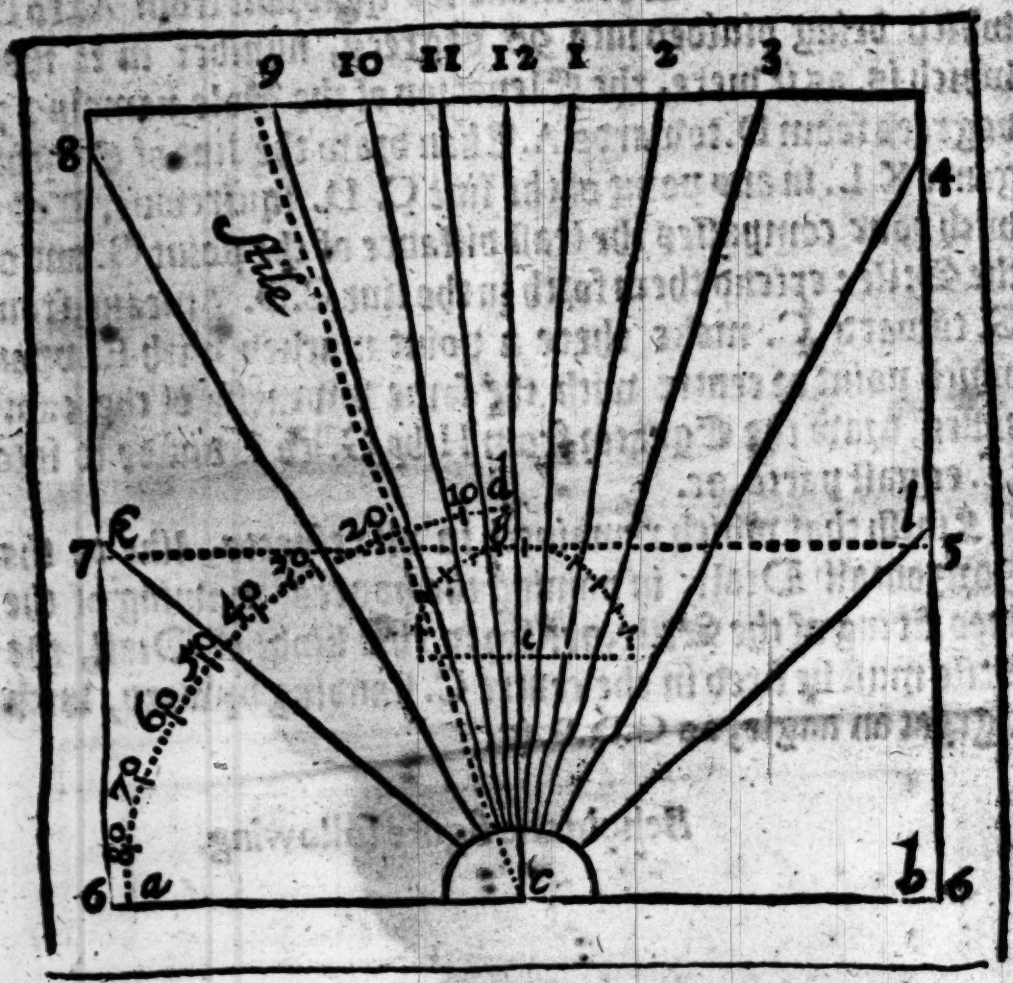
In Delineation of this Diall, draw a line Parallell to the Horizon A. B. draw another C. D. making right angles with the line A. B. Then make the quadrant from A. to D. which being divided into 90. degrees, number in it that, which is, as it were, the Elevation of the Pole, namely 17. degrees from D. towards A. Then draw the line of Contingence K. L. in any point of the line C. D. squirewise. Take with your compasses the least distance of the point G. and of the Stile: extend them forth in the line C. D. I meane, from G. towards C. make there a point marked with E. upon which point or centre with the same wideneſſe of the compasses, draw the Equator from H. by G. to I. divide it into 12. equall parts, &c.

Finish that which remaineth in all respects, like to the Horizontall Diall, in naming the houres, drawing of the lines, fixing of the Stile, &c. for in this kinde of Diall, the Stile must be fixed in the centre C. standing upward, with so great an angle, as C. D. F. is.

Behold the figure following.



A South Reclining Erect.



The making of a North Diall Reclining Direct.

Chap. 12.

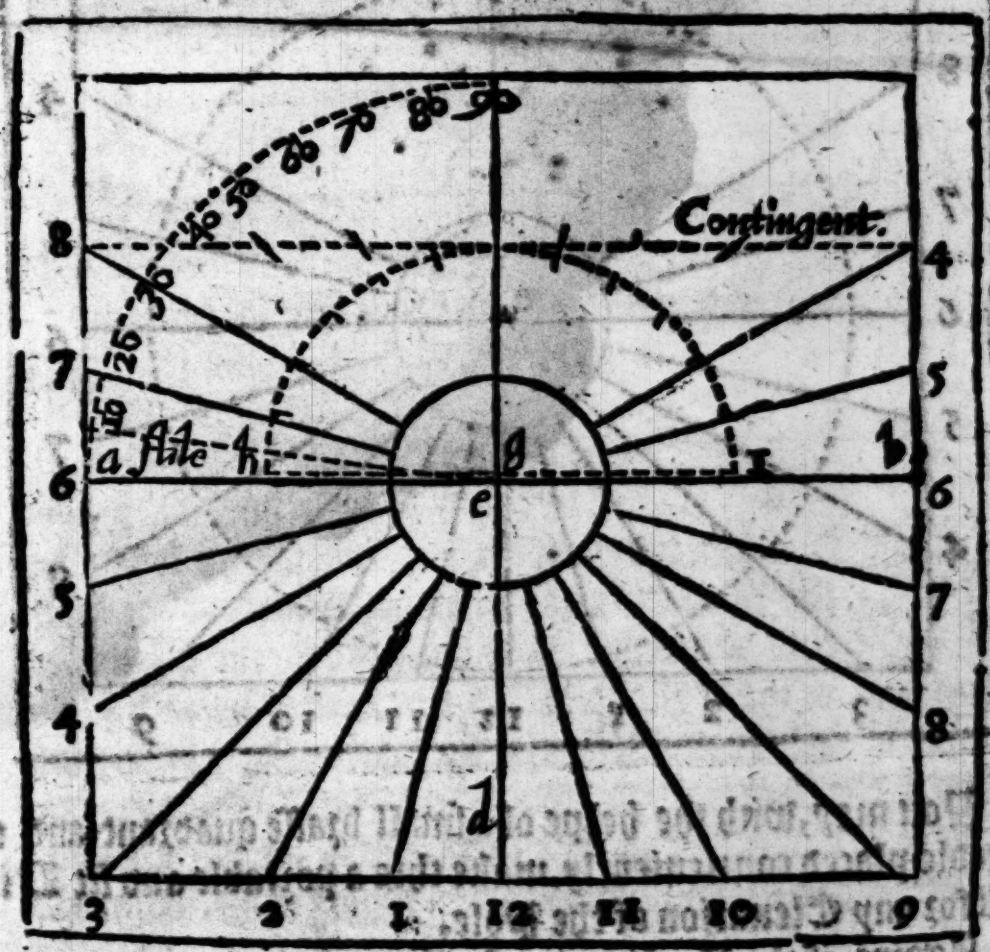
IN these kindes, if the Reclination be lesse then the Elevation of the Pole, subtract that from this, and keepe the remainder for the Elevation of the Pole: according to which Elevatiõ, make a North Diall Erect Direct, and it will be fit for your plat. In which the houres about Nowne are placed, being profitable onely in Summer: and not then, unlesse the Reclination be greater then the distance of the Tropike of ♋, from the Zenith.

Zenith. And the more your Diall reclineth, the longer time it will shew in Summer.

Example of a North Diall Reclining 45. degrees.

FIrst I take the Elevation of the Pole (which wee account 52.d.) out of the Reclination of the plat, which is 45.d. and there remaine 7.d. which shall bee in place of the Elevation of the Pole.

Then for the drawing of it, resort to the North Erect Direct, because their Delineation is like: remembring alwaies to call that which remaineth, the Elevation of the Pole: which in this example is but 7.d. In the figure following you see, that most part of the houre lines be drawne opposite from the Contingent, beyond the centre E. as you must doe in any of this kinde, if you will haue the houres about noone.

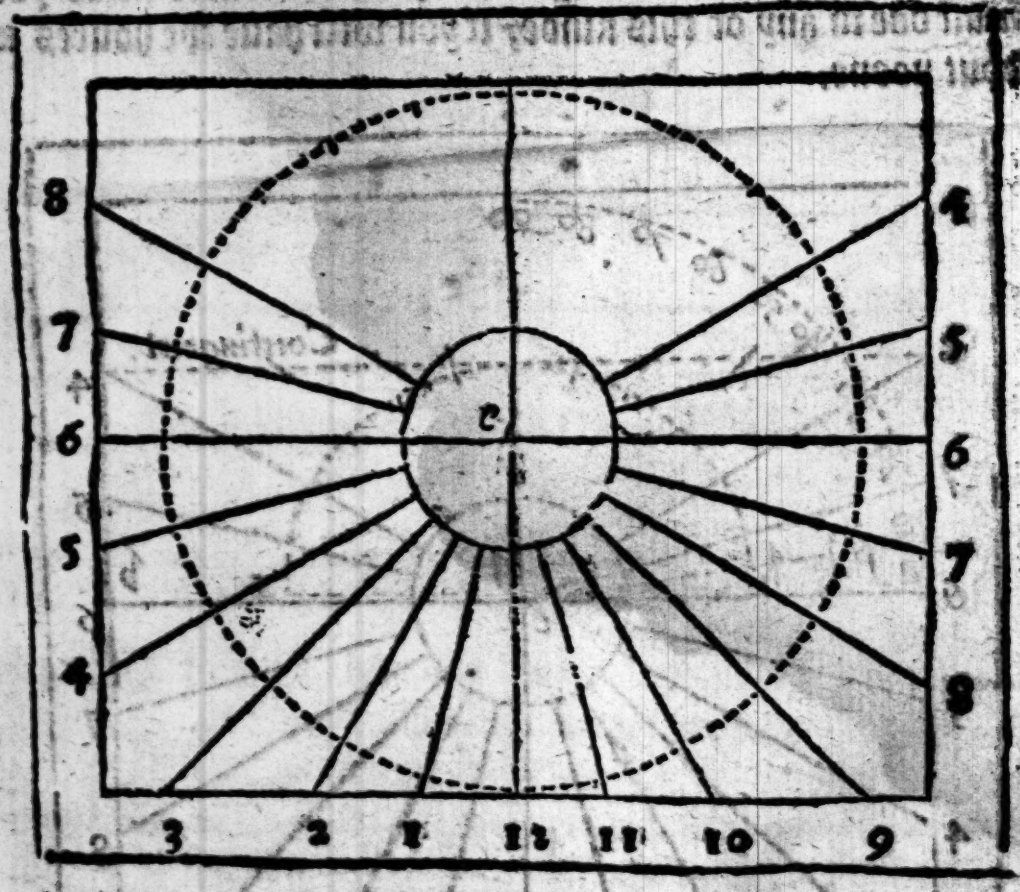


Example

Example of a North Diall Reclining 52. degrees.

But if the reclination be equall with the Elevation of the Pole: then describe a circle upon the centre E. & divide it into 24. equall parts, beginning the diuision at the 12. houre. Draw by those points, lines for the houres from the centre E. so many as shall be necessary: erecting the Stile (being some small wyer) in the centre E. right vp. This kinde of Diall serueth only when the Sunne is in the North signes, which be ♈, ♉, ♊, ♋, ♌, ♍.

A North Reclining Direct.



You may, with the helpe of a small brasse quadrant and a needle placed conueniently, make this a portable and fit Diall for any Elevation of the Pole.

Againe, if the Reclination shall exceede the Elevation of

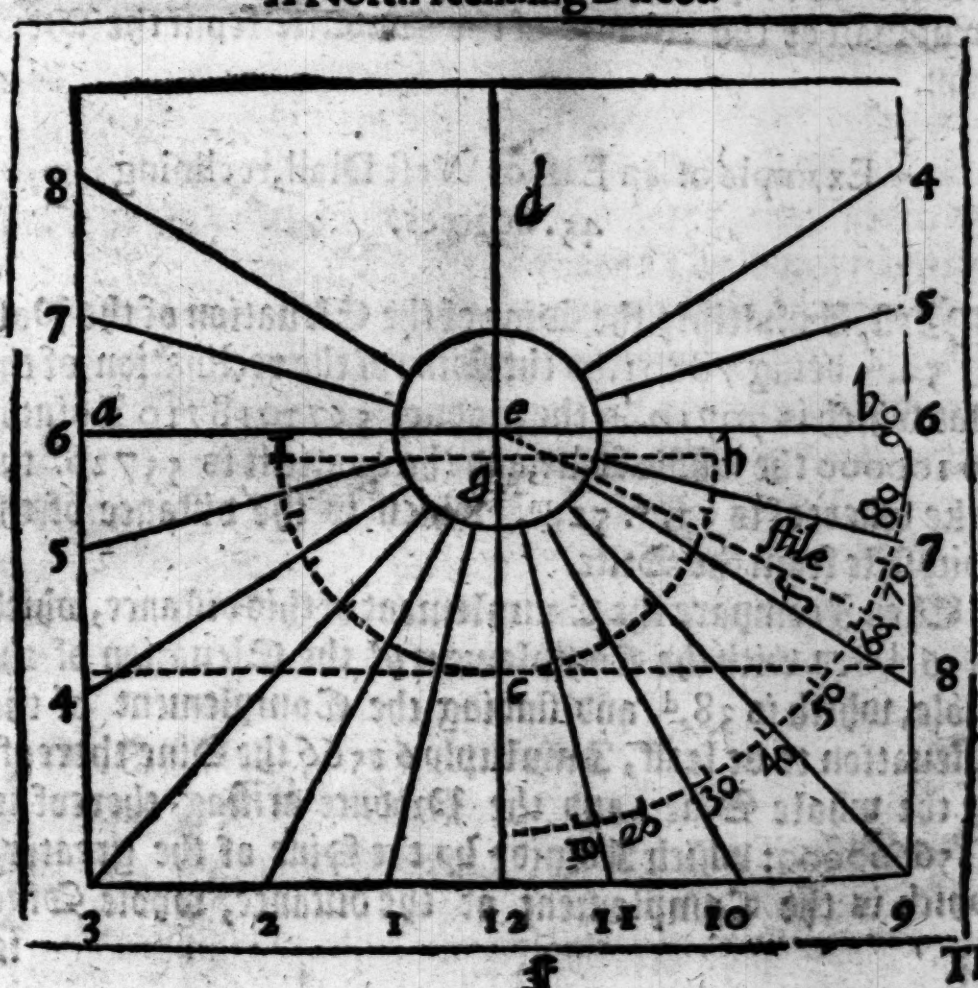
the

the Pole: adde the complement of the reclination to the Elevation, and with that number, as if it were the Elevation of the Pole, make your Dial altogether like a Horizontall, and it shall be fit for your plat. In which notwithstanding in winter, very few houres shew, and those about noone: and yet not these, unlesse the reclination shall bee greater, then the highest bending of the Tropike of ♑, from the Zenith.

Example of a North Diall reclining 80. d.

FIrst, adde the complement of the reclination of the plat, which is 10. d. to the Elevation of the Pole 52. d. and with the totall number 62. d. as if it were the Elevation of the Pole, make a Horizontall Diall, as is shewed Chap. 3. Alwaies remember to call the two numbers added together, The Elevation of the Pole.

A North reclining Direct.



F The

The making of an East and West Diall reclining.

Chap. 13.

First multiply the Sine of the eleuation of the Pole, by the Sine of the Reclination of the plat, and diuide the product by the whole Sine: whereof shall come a quotient, whose arke is the distance of the Stile, from the Substile.

Compare the Complement of this distance with the Complement of the Eleuation of the Pole, and which you shall finde least, multiply the Sine thereof by the whole Sine, parting the Product by the Sine of the greater. The quotient shall yeeld an arke, whose Complement shall be the distance of the Substile from the Meridian.

Example of an East or West Diall, reclining 45. degrees.

First, I multiply the Sine of the Eleuation of the Pole 52.^{d}. being 78801. by the Sine of the reclination of the plat, which is 70710. & the product 5572018710 I diuide by 100000 the whole Sine, and the quotient is 55720. the arke whereof is 33.^{d}. 52.^{m}. which is the distance of the Substile from the Stile.

Then I compare the Complement of this distance, which is 56.^{d}.8.^{m}. with the Complement of the Eleuation of the Pole, which is 38.^{d}. and finding the Complement of the Eleuation to be least, I multiply 61566 the Sine thereof, by the whole Sine: and the Product arising thereof is 6156600000: which I diuide by the Sine of the greater, which is the Complement of the distance, whose Sine

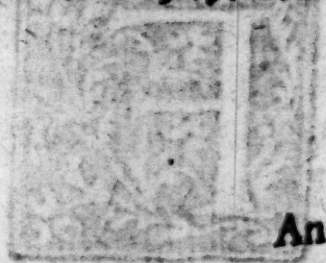
is

is 83033. And the quotien 74141. yeeldeth an arke 47.d. 51.m. whose Complement is 42.d.9.m. which is the distance of the Substile from the Meridian.

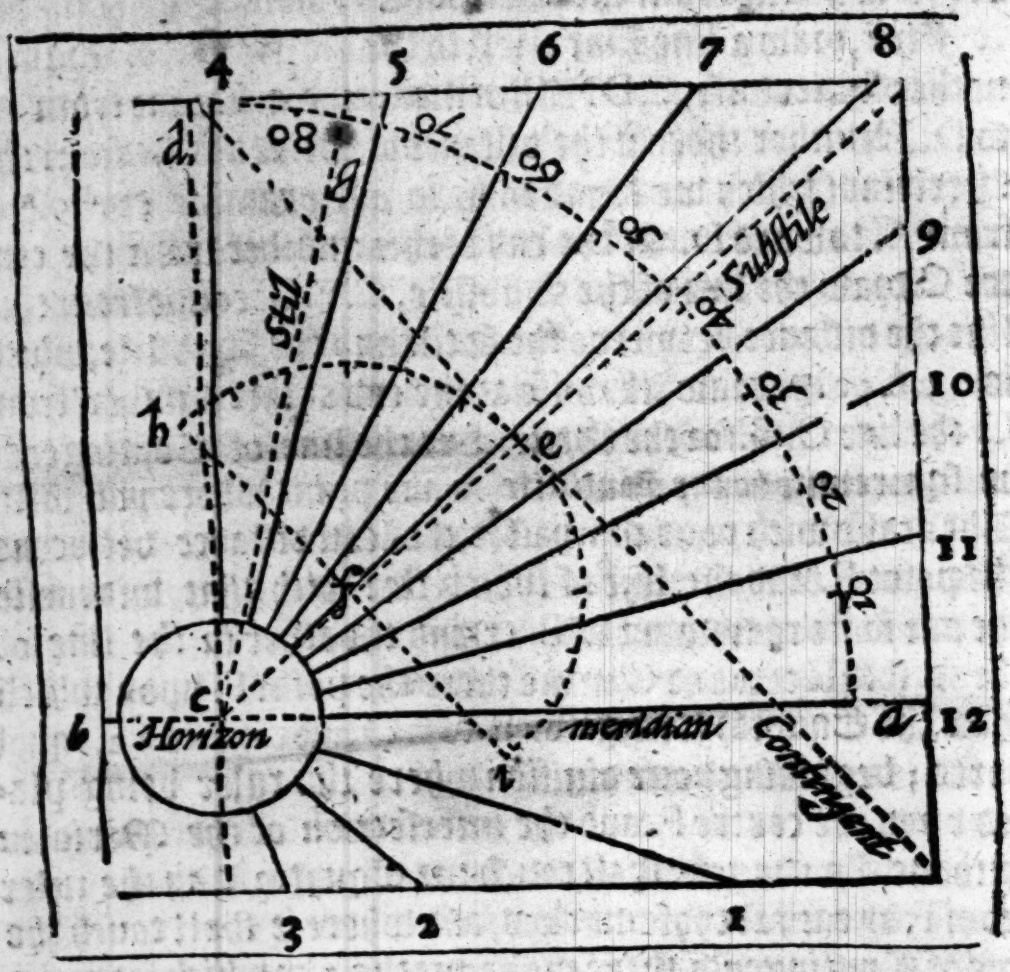
First, draw a line Parallell to the Horizon A. B. draw another squirewise, C.D. Then make the quadrant from A. to D. Number therein the distance of the Substile from the Meridian (which we found to be in our example 42.d.9.m.) from A. toward D. At the end of this number from the centre C. draw the line of the Substile, C.E. Account from this line the distance betweene the Stile and the Substile, which is 33.d.52.m. draw likewise at the end of this number from C. the line C.G. for the Stile. Let the line of Contingence be squirewise to the Substile in any point where you will. Then take with your compasses the least distance betweene the point E. and the line of the Stile: with that wideneſſe the one foote remaining in E. extend the other in the line of the Substile toward C. make there the point F. upon which draw the Equator from H. by E. to I. Diuide it into 12. equal parts; beginning your diuision where the ruler being placed upon the centre F. and the intersection of the Meridian with the Contingent shall touch the Equator. Lay the ruler from F. by each of those markes, and where it shall touch the line of Contingence, there make marks: by which from the centre C. draw the houre lines so many as shall be necessary. The line A.B, is the Meridian, and sheweth the 12 houre. Finish al other things, as in the rest before you were taught.

The delineation of the Figure.

Note that if it be an East diall, you must make the quadrant from A. to D. If a west, from B. to D. Finish the residue as before, &c.



An East or West reclining.



The making of a South reclining declining Diall.

Chap. 14.

First, in this kind, as in other which follow, you must find out and place the Meridian, the Substile, and the Stile, which being done, that which remaineth is finished as in those before.

Therefore the Declination and the Reclination of the plat being knowne by your Instrument, multiply the Sine of the declination by the

the Sine of the complement of the Reclination, diuiding the product by the whole Sine. The quotient Sine shall yeeld an Arke, whose complement shall be named the Complement to be repeated.

Afterward augment the Sine of the Complement of the Declination, by the whole Sine, diuide the Product by the Sine of the complement to be repeated: whereof shall come a Sine, whose Arke shall be the distance of the Meridian from the Horizon.

Againe, multiply the Sine of this distance, by the Sine of the Complement of the Reclination, parte the Product by the whole Sine, the arke of whose quotient shalbe called the Eleuation of the Meridian.

Then compare this Eleuation of the Meridian, with the Eleuation of the pole, and which you shall finde least, subtract that from the greater, and that which remaineth keepe, (for it shall be called the difference kept) being mindefull which of them was the greatest.

This done, multiply the Sine of the Complement to bee repeated, by the Sine of the difference kept: diuiding the Product by the whole Sine, whereof shall come a Sine, whose arke shalbe the distance of the Stile from the substile.

To conclude, compare the Complement of this distance with the complement of the difference kept, and which you shall find least, multiply the Sine therof by the whole Sine: part the Product by the Sine of the greater, and thereof shall come a Sine, the Complement of whose arke shalbe the distance of the Substile from the Meridian.

Example of a South Diall { Declining 18.d. / Reclining 25.d.

First looke out in the Table the Sine of the Declination, which is 30901. Then the Complement of the Reclination being 65.d. the Sine hereof is 90630. Afterward multiply 90630. by 30901. and the product 2800557630

diuide by the whole Sine, which is 100000. the quotient shall be 28005. whose arke is 16.d.16.m. The complement whereof being 73.d. 44.m. is the Complement to be repeated.

This done, multiply 95105 the Sine of the Complement of the Declination 72.d. by the whole Sine 100000. the product shall be 9510500000. which being diuided by 95996 the Sine of the complement to be repeated, the quotient shall be 99071, whose arke is 82.d. 11.m. which is the distance of the Meridian from the Horizon.

Afterward augment the Sine of this distance 99071. by the Sine of the complement of the Reclination, which is 90630, and the product 8978804730 part by the whole Sine: & the quotient 89788 shall yeeld an arke 63.d.53.m. which is the Eleuation of the Meridian.

Then compare the Eleuation of the Meridian, with the Eleuation of the Pole, which in this example is 52.d. and finding the Eleuation of the Pole to be least, substract this, (namely 52.d.) from 63.d.53.m. the Eleuation of the Meridian, & there remaineth 11.d.53.m. which is ỹ difference kept.

Now multiply 95996 being the Sine of the Complement to bee repeated, which is 20591. the product is 1976653636, which diuided by the whole Sine, the quotient shall be 19766, whose arke 11.d.24.m. is the distance of the Stile from the Substile.

Then to conclude, the Complement of this distance, which is 78.36.d.m. being compared with the Complement of the difference kept, which is 78.d.7.m. you shall finde the Complement of this difference kept to be least, wherefore multiply 97856 the Sine thereof, by the whole Sine, and the product 9785900000. part by the Sine of the greater, to wit, of the Complement of the distance of the Stile from the Substile, wich is 98027. the quotient shall bee 99825. whose arke is 86.d.37.m. The Complement whereof is 3.d.23.m. which is the distance of the Substile from the Meridian.

There

There be three sundry kinds of these Dials, the one differing from the other.

The first kind.

Marke therefore, if the Eleuation of the Meridian be greater then the Eleuation of the Pole, draw a line parallell to the Horizon A. B. out of the middest whereof extend another C.D. squirewise to the line A.B. make the quadrant from A. to D. number therein from A. towards D. the distance of the Meridiã from the Horizon, which is 82.d.11.m. at the end hereof from the centre C. draw the line C. E. for the Meridian.

From which account backward towards A. the distance of the Substile from the Meridian, which is 3.d.23.m. draw at the end of this number the line C. F. for the Substile.

Then from the Substile toward A. number the distance of the Substile from the Stile 11. degrees 24. minutes, and at the end therof extend the line C.G. which shall represent the Stile. This done, in the line of the Substile in the point F. (which you may take where you will in the Substile) draw the line of Contingence squirewise to the Substile. Then take the least distance of the point F. from the Stile.

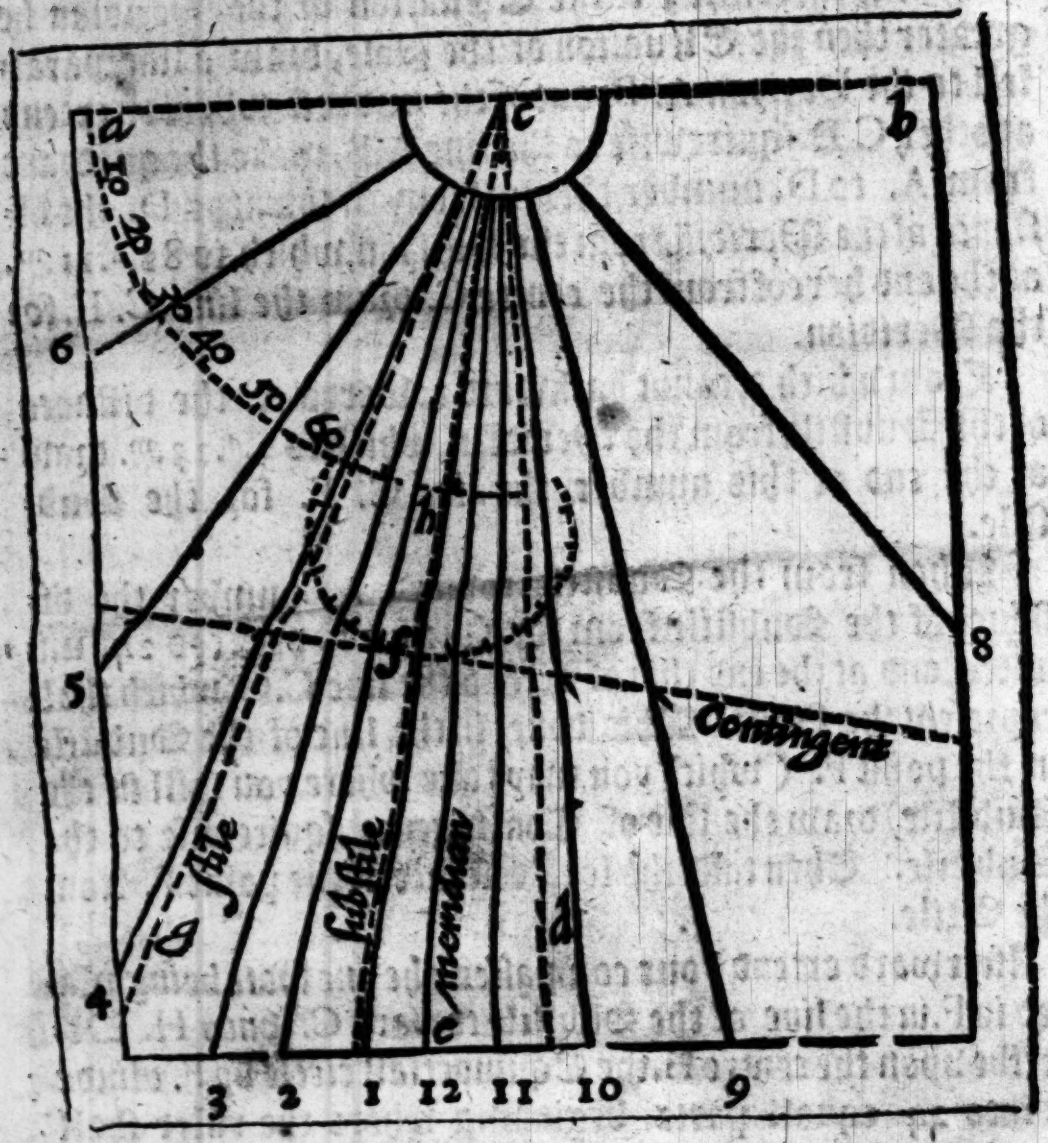
Afterward extend your compasses, the one foote being placed in F. in the line of the Substile toward C. vnto H. Describe vpon the centre H. the Equinoctiall circle by F. diuide it into 24. equall parts, beginning where the ruler shall touch the Equator, being placed vpon the centre H. and vpon euery marke of the Equator, and where the ruler shall touch the line of Contingence, there make markes, by which, from the centre C. draw the houre lines so many as shall bee necessary, C. E. alwaies shewing the 12. houre. Let the Stile hang directly ouer the Substile with so great an angle as F.C.G. is: fixing it in the centre C. pointing

downeward

downeward to the Pole Antarticke.

Place the line A. B. parallel to the Horizon, hauing afterward, as other preparatiue lines, no vse.

A South Declining Reclining.



The second kinde.

But if the Elevation of the Pole, and the Elevation of the Meridian be found equall, the making of your Diall differeth from the former: yet the finding out of the Meridian and the Subtile, &c. is wrought as in the other before, whither

whither you may resorte. It shall be sufficient here to shew an example of this kinde.

Example of a South Diall, whose { Declination is, 32.d. / Reclination is, 33.d.30.m. / Elevation of the Pole is, 52.d.2.m.

First, I multiply 52991 the Sine of the declination, by 83388 the Sine of the Complement of the Reclination, and the product 4418813508 arising thereof, I divide by the whole Sine: the quotient Sine 44188 yeeldeth an arke 26.d.14.m. whose complement being 63.d.46.m. is the complement to be repeated.

Then I increase the Sine of the Complement of the declination, which is 84804, by the whole Sine, and the product is, 8480400000: which I parte by 89700, being the Sine of the complement to be repeated. The arke of whose quotient Sine 94541 being 70.d.59.m. is the distance of the Meridian from the Horizon.

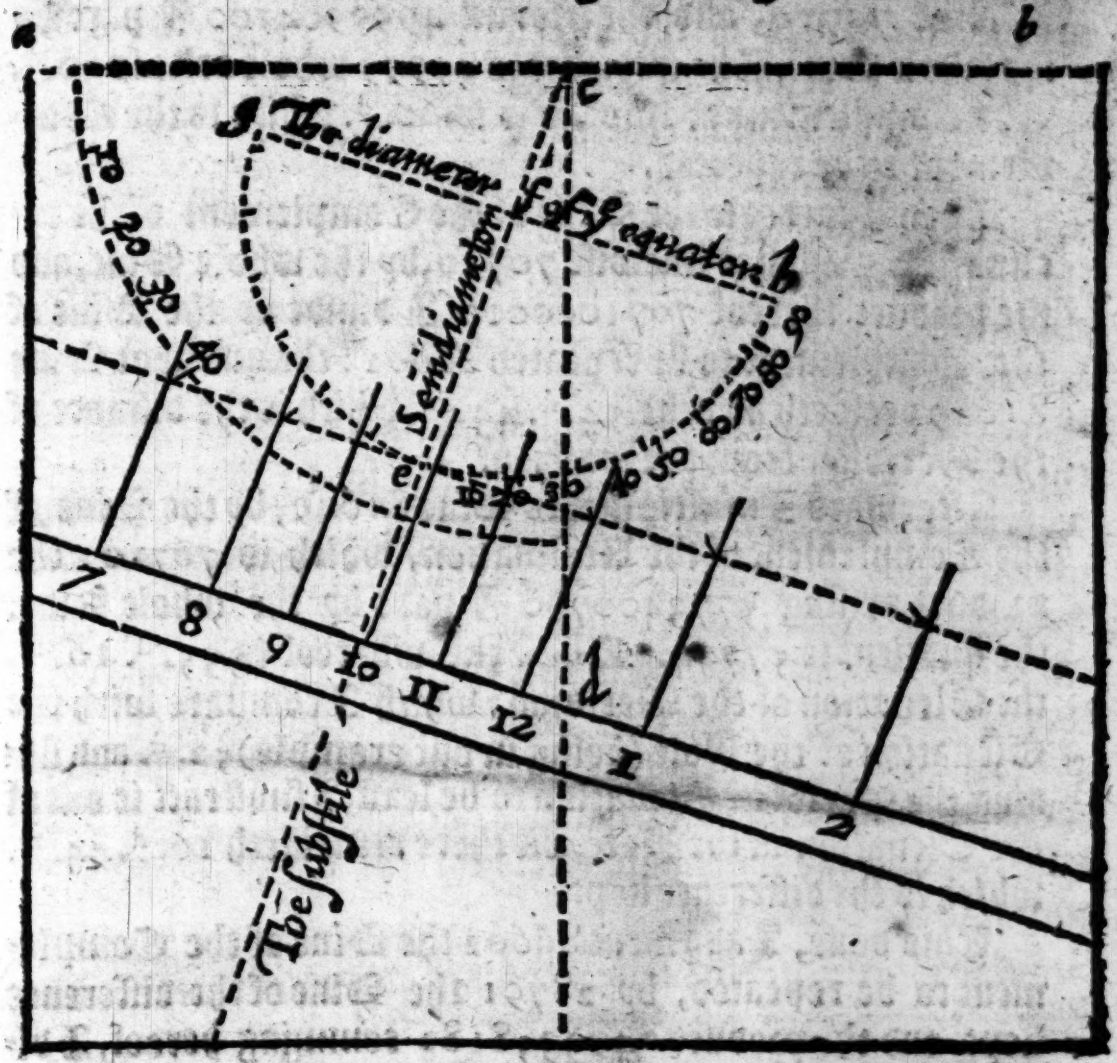
This done, I multiply this Sine 94541, by the Sine of the complement of the reclination, which is 83388, and the product arising hereof, being 7883584908, I divide by the whole Sine: the quotient thereof is 78835, whose ark 52.d.2.m. is the Elevation of the Meridian, which I compare with the Elevation of the Pole, and finding them equall, I end my worke heere. For this shall be sufficient in this kinde of Diall, as you may more plainely perceive by the delineation of the Figure.

Wherefore if the Elevation of the Pole, and of the Meridian be found equall, (as in this example it is) make a line parallel to the Horizon A. B. Draw another C. D. making right angles with the line A. B. Draw the quadrant from A. to D. number therein the distance of the Meridian from the Horizon from A. toward D. which is 70.d. 59.m. being here in place of the Substile. Then draw the line of Contingence squire-wise to the Meridian C.E. (which is also the

Substile C.E. in any point therof, as before. Place one foote of your Compasses in the intersection E. then set the other foote in the Meridian (or Substile) being of any wideneſſe: make there the point or centre F. vpon which centre draw the halfe Equator from G. by E. to H. Diuide the one halfe therof from E. towards H. into 90.d. Account therein from the Meridian E. towards H. the declination of the plat 32.d. place the ruler vpon the centre F. and the end of this number, and where it shall touch the Contingent line, there make a marke, by this marke you must draw a line squirewise to the Contingent line, which shall be for the 12. houre. And where the ruler shall touch the Equator, there begin to diuide it into 12. equall parts, by which lay the ruler from the centre F. making in the line of Contingence markes for the other houre-lines, all which shall cut the Contingent line squire-wise. Note that sometime in diuiding of the Equator, the two parts at both ends *next to the Semidiameter G. H. shall both* of them make but one whole part, vnleſſe you will make a whole circle for the Equator, and diuide it into 24. parts.

Let the Stile be a small wyer standing right vp in the point E. being so long as the Semidiameter of the Equator. It may be also a plate of iron or brasse fastened in the Substile, so broade as the Semidiameter is, as in the East and Weſt erect dials, &c. Let the line A. B. bee parallele to the Horizon. Finish all other things as before.

A South reclining declining.



The third kinde.

If the Eleuation of the Meridian be lesse then the Eleuation of the Pole, the making of this Diall is vnlike to both the other mentioned before, yet the finding out of the distance of the Stile from the Substile, is done like to the first kinde, as by the example following may appeare.

Example of a South Diall { Declining 45. d. / Reclining 45. d. / Eleuation of the Pole 52. d.

First, I multiply the Sine of the declination, being 70710

by the Sine of the complement of the reclination which is likewise 70710, and the product 4999904100 I part by the whole Sine. The quotient is 49999 whose arke is 30.d. The Complement of this Arke is 60.d. which is the Complement to be repeated.

Then I increase the Sine of the Complement of the declination, which is likewise 70710, by the whole Sine, and the product thereof 7071000000 I diuide by the Sine of the Complement to be repeated 86602: the quotient Sine 81649 yeeldeth an arke 54.d. 44.m. which is the distance of the Meridian from the Horizon.

Afterward I multiply this Sine 81649, by the Sine of the Complement of the Reclination, which is 70710: the product arising 5773400790 I part by the whole Sine, the quotient is 57734. The arke whereof is 35.d. 16.m. the Eleuation of the Meridian: which I compare with the Eleuation of the Pole (being in our example) 52.d. and finding the Meridian Eleuation to be least, I substract it out of the Eleuation of the Pole, and there remaineth 16.d. 44.m. which is the difference kept.

This done, I augment 86602 the Sine of the Complement to be repeated, by 28791 the Sine of the difference kept, and the product 2493358182 comming thereof, I diuide by the whole Sine, the quotient Sine 24933 yeeldeth an arke 14.d. 26.m. the distance of the Stile from the Substile.

Now comparing the Complement of this distance being 75.d. 34.m. with the Complement of the difference kept, which is 73.d. 16.m. and seeing the Complement of the difference kept to be least: I multiply 95765 the Sine thereof, by the whole Sine, and the product 9576500000 I diuide by 96843 the Sine of the complement of the distance, and 98886 shall be the quotient thereof, whose arke is 81.d. 27.m. The Complement of this arke is 8.d. 33.m. which is the distance of the Substile from the Meridian.

In the Delineation of this Diall, draw first as before a

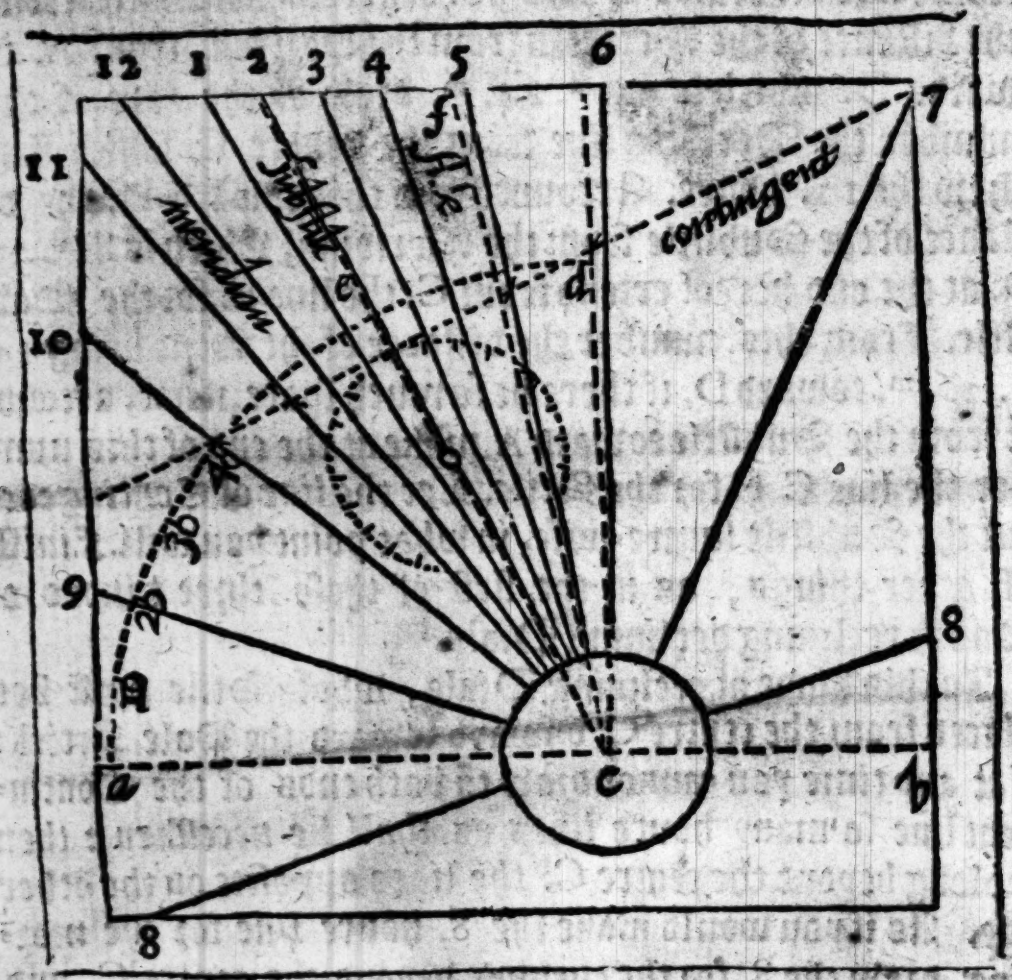
line

line Parallele to the Horizon A.B. extend another C.D. making right angles with the line A. B. Draw the Quadrant from A. to D. diuide it into 90. degrees. In which account the distance of the Meridian from the Horizon, from A. towards D. which is 54. d. 44. m. draw at the ende of this number the Meridian line from the centre C. which shall shew the 12. houre. Account from this toward D. the distance of the Substile from the Meridian, which is 8. d. 33. m. at the end hereof extend from C. the line E. for the Substile. From this, number the distance of the Stile being 14. d. 26. m. toward D. if there be so much space, if not, account it from the Substile toward A. make at the end of this number the line C. F. for the Stile. Let the line of Contingence cut the Substile squire-wise, in what point you will. Finish all other things, as in the first of these three kindes of South reclining declining Dials.

In this kinde of reclining Dials, whose Stile must bee placed from the centre C. vpward toward the Pole Artick: if at any time you cannot draw to both ends of the Contingent line so many houre lines as shall be necessary: then prolong beyond the centre C. the lines opposite on the other side. As if you would make the 8. houre line for the morning, draw the 8. for the euening beyond the centre C. and you shall haue your desire.

Note that moreouer, in this kinde contrary to the other before, if the plat decline toward the West, (as in this example it doth) then draw the quadrant towards the West, &c. But if the Declination be towards the East, make the quadrant towards the East.

A South reclining, declining.



The making of a North reclining declining Diall.

Chap. 15.

The first kinde.

IN this kinde, as in the South before: first, multiply the Sine of the declination, by the Sine of the Complement of the Reclination: parting the product by the whole Sine. The quotient Sine thereof shall yeeld an Arke, whose Complement shall be called the Complement repeated.

Then

Then increase in the Sine of the complement of the Declination by the whole Sine, diuide the product by the Sine of the Complement repeated: the quotient Sine thereof will giue an Arke, which shall be the distance of the Meridian from the Horizon.

The same quotient Sine multiply by the Sine of the Complement of the reclination: and the number arising part by the whole Sine: the Arke of this quotient is the Eleuation of the Meridian.

Now adde the Eleuation of the Pole to the Eleuation of the Meridian, and the totall number or Arke hereof, wee wil call the compounded Arke. And if the compounded Arke be lesse then 90. degrees: then multiply the Sine thereof, by the Sine of the Complement repeated, diuiding the product by the whole Sine: and hereof shall arise a quotient Sine, whose arke shal be the distance of the Stile from ꝑ Substile.

Now compare the Complement of this distance, with the Complement of the compounded Arke: and increase the Sine of the lesse by the whole Sine, part the product by the Sine of the greater: and thereof shall come a Sine, the Complement of whose Arke shal be the distance of the Substile from the Meridian.

But marke here the diuersitie which doth arise by reason of the compounded Arke: for hereby you shall haue three sundry waies, both in finding out the distances betweene the Meridian and the Horizon, the Stile and Substile, &c. And likewise in the declination of the figure. Whereof ariseth three sundry kinds of Dials: the first of them being already taught.

The second kinde.

If the compounded arke be iust 90. degrees: then the distance of the Stile from the Substile shall bee the Complement repeated: and the distance of the Substile from the Meridian shall be also 90. degrees.

Note

Note that in the working hereof, there is no difference from the first kinde. For here as in the other before, you shall first finde out the complement repeated: then the distance of the Meridian from the Horizon: Afterward the Elevation of the Meridian, which being added to the Elevation of the Pole, if the totall number bee iust 90.d. you shall not neede to proceede forward, for this (as before I made mention) shall bee the distance of the Meridian from the Substile.

In this kind you shall haue no intersection of the Meridian and the Contingent line: therefore you shall begin the division of the Equator at the line of the Substile, which shall shew the 6. houre, either in the morning, or euening, according as the plat doth decline.

The third kinde.

But if the compounded Ark be greater then 90. degrees, substract it from 180, and that which remaineth shall be called the difference kept. Then multiplie the Sine of the Complement repeated, by the Sine of the difference kept, diuiding the product by the whole Sine, hereof shall come a Sine, whose Arke shall be the distance of the Stile from the Substile.

Then compare the Complement of this distance, with the Complement of the difference kept, increasing the Sine of the lesser by the whole Sine, and parting the product by the Sine of the greater: whereof shall come a Sine, the Complement of whose arke, being taken from 180. degrees, the remaynder shall shew how much the line of the Substile must be distant (vpward by the Horizon) from the Meridian. For the better vnderstanding of these three kinds, marke these three examples following, with the delineation of their figures.

Example

Example of a North Diall, whose { Declination is, 45. d. / Reclination 45. d. / Eleuation of the Pole 52. d.

First, I worke this altogether like to the South reclining 45. d. declining 45. d. vntill I haue found out the Eleuation of the Meridian.

Then I adde the Eleuation of the Meridian which is, 35. d. 16. m. to the Eleuation of the Pole 52. d. the totall number is 87. d. 16. m. which is the compounded arke: and being lesse then 90. d. I proceede with this arke, &c.

Now therefore I multiply the Sine of this compounded arke, which 99884, by the Sine of the complement to bee repeated being 86602, and the product 865015 4168 I part by the whole Sine. The quotient thereof is 86501, whose arke 59. d. 54. m. is the distance betweene the Stile and the Substile.

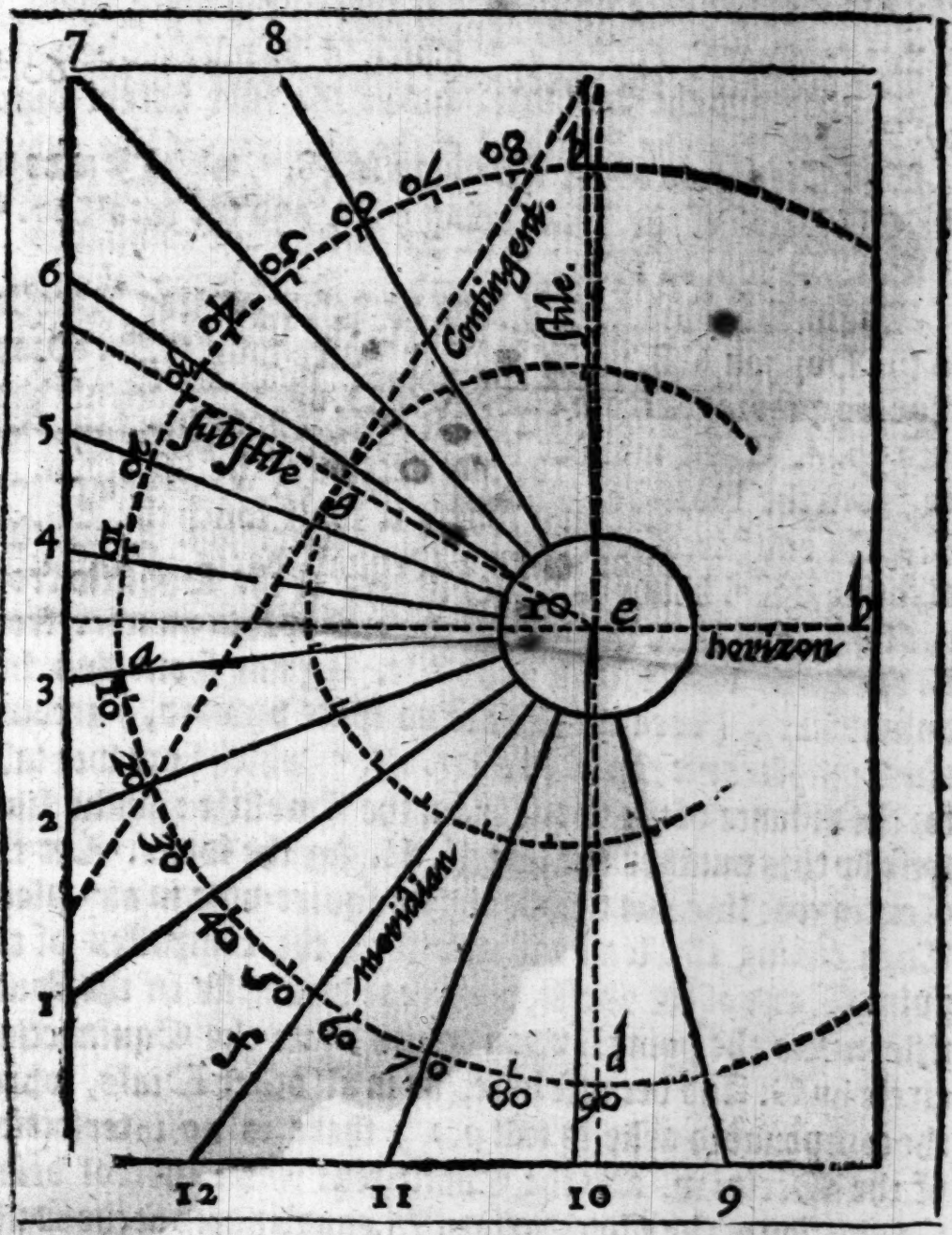
Then I compare 30. d. 6. m. being the Complement of this distance, with the Complement of the compounded arke, which is 2. d. 44. m. and finding this least, I increase 4768 the Sine thereof, by the whole Sine, diuiding the product, which is 476800000, by 50151 the Sine of the greater: the quotient Sine yeeldeth an arke 5. d. 27. m. the Complement hereof 84. d. 33. m. is the distance of the Substile from the Meridian.

In drawing of this Diall, first as before, make a line Parallele to the Horizon A. B. Then extend the line C. D. cutting the other squire-wise. Marke the intersection or centre with E. draw thereupon a circle A. B. C. D. whose two quadrants at the least, toward A. (if the plat decline Westward, or else toward B. if it decline Eastward) being diuided into 90. d. each of them, number therein from A. towards D. the distance of the Meridian from the Horizon, which is 54. d. 44. m. and at the end hereof from the centre E. draw the line F. for the Meridian, or 12. houre. Account

from this vpward toward C. the distance of the Substile from the Meridian, being 84.d. 33.m. make likewise at the end of this number from E. the line for the Substile. Againe number from hence vpward (if there be so much space, or else downward) 59.d. 54.m. which is the distance betweene the Stile and the Substile, and at the ende hereof drawe the line H. for the Stile. Let the Contingent line cut the Substile squire-wise in the point G. which you may take in any place of the Substile. Then with your compasses the least distance of this point G. and the Stile being taken, with that wideneſſe extend them forth in the line of the Substile toward E. making there the point I. vpon which draw the Equator or Equinoctiall circle. This done place the ruler vpon the centre I. and the intersection of the Meridian and the Contingent line, and where it shall touch the Equator there begin to diuide it into 24. equall parts. Finish all other things, as in those which went before.

A North

A North reclining declining.



The second kinde of North Diall, reclining 45. degrees 14. minutes, declining 38. degrees.

IT shall not bee necessary to shew an example of this second kinde, because the Complement repeated, the distance of the Meridian from the Substile, and betweene

the Stile and Substile, &c. is found out altogether like to the other before, and that which followeth. Therefore it sufficeth to set downe the number of the distances.

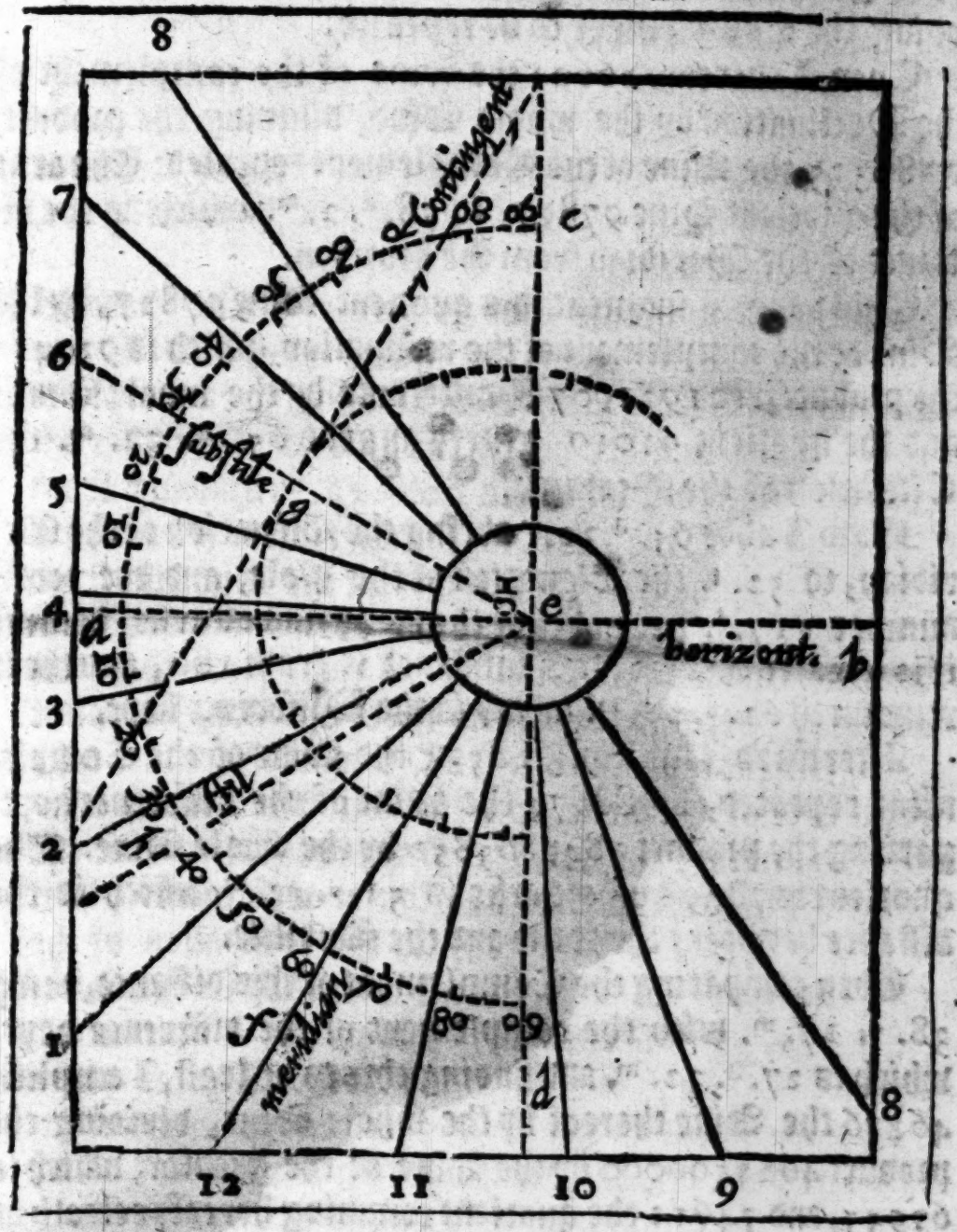
First, the Complement repeated is, 64. d. 18. m.

The distance of the Meridian from the Horizon is, 60. d. 59. m.

The Elevation of the Meridian is 38. d. which I adde to the Elevation of the Pole being 52. d. and the totall 90. d. is the compounded arke.

Draw therefore in this kind as before, a line Parallel to the Horizon A.B. make another squire-wise, C.D. Draw the two quadrants from C. by A. to D. dividing each of them into 90. d. Then number herein the distance of the Meridian from the Horizon, which is 60. d. 59. m. drawing from E. at the end hereof, the line F. for the Meridian. From this account 90. d. being here the distance of the Substile from the Meridian: and likewise at the end of this number from E. draw the line for the Substile. Againe from this line downeward, (because there is no space vpward,) account the Complement repeated 64. d. 18. m. which here wee take for the distance of the Stile from the Substile: make likewise by this number the line E. H. for the Stile. Let the Contingent line cut the Substile squire-wise in any place. Then taking the least distance with the compasses of the point G. and of the Stile, with that wideneſſe in the Substile, make the point I. vpon which draw the Equinoctiall circle by G. And because here, (as in all other Dials, where the compounded arke is iust 9. d.) there is no intersection of the Meridian, and the Contingent line: thereof being the division of the Equator into 24. equall parts at the Substile, which in this kinde shall shew the sixth houre, either in the euening or morning, according to the declination of the plat. Place the ruler vpon the centre I. and so many of these parts as you can, making markes in the line of Contingence as before, draw the houre lines by them, &c. finish the rest as in the other.

A North Declining Reclining.



Example of the third kinde of North Diall before mentioned. { Reclining 21. d. 30. m. / Declining 30. d.

Here first, as before I multiply the Sine of the Declination being 50000, by 93041 which is the Sine of the

complement of the reclination and the product 46520700000 I part by the whole Sine: the quotient 46520 yeeldeth an arke 27. d. 43. m. The complement whereof is 62. d. 17. m. being the Complement to be repeated.

Then I encreale 86602 the Sine of the complement of the Declination by the whole Sine, diuiding the product, by 88525 the Sine of the Complement repeated: The arke of the quotient Sine 97827, is 78. d. 2. m. which is the distance of the Meridian from the Horizon.

This done, I augment this quotient Sine 97827, by the Sine of the complement of the reclination, which is 93041: the product 9101921907 I distribute by the whole Sine: and the quotient 91019 giueth an arke 65. d. 32. m. the Eleuation of the Meridian.

Now I adde 65. d. 32. m. being the Eleuation of the Meridian, to 52. d. the Eleuation of the Pole, and the totall number 117. d. 32. m. being the compounded arke, because it is greater then 90. d. I substract it from 180, and there remaineth 62. d. 28. m. which is the Difference kept.

Afterward I multiply 88525 the Sine of the Complement repeated, by 88674 the Sine of the difference kept, parting the product 7849865850 by the whole Sine. The quotient is 78498 whole arke is 51. d. 43. m. which is the distance betweene the Stile and the Substile.

Then comparing the Complement of this distance, being 38. d. 17. m. with the complement of the difference kept, which is 27. d. 32. m. and finding this to be least, I amplifie 46226 the Sine thereof by the whole Sine, diuiding the product 4622500000 by the Sine of the greater, which is 61955, and 74612 the quotient comming hereof yeeldeth an arke 48. d. 15. m. whose Complement being 41. d. 45. m. I take out of 180, and the remainder is 138. d. 15. m. the distance of the Substile from the Meridian.

The delineation of the Figure.

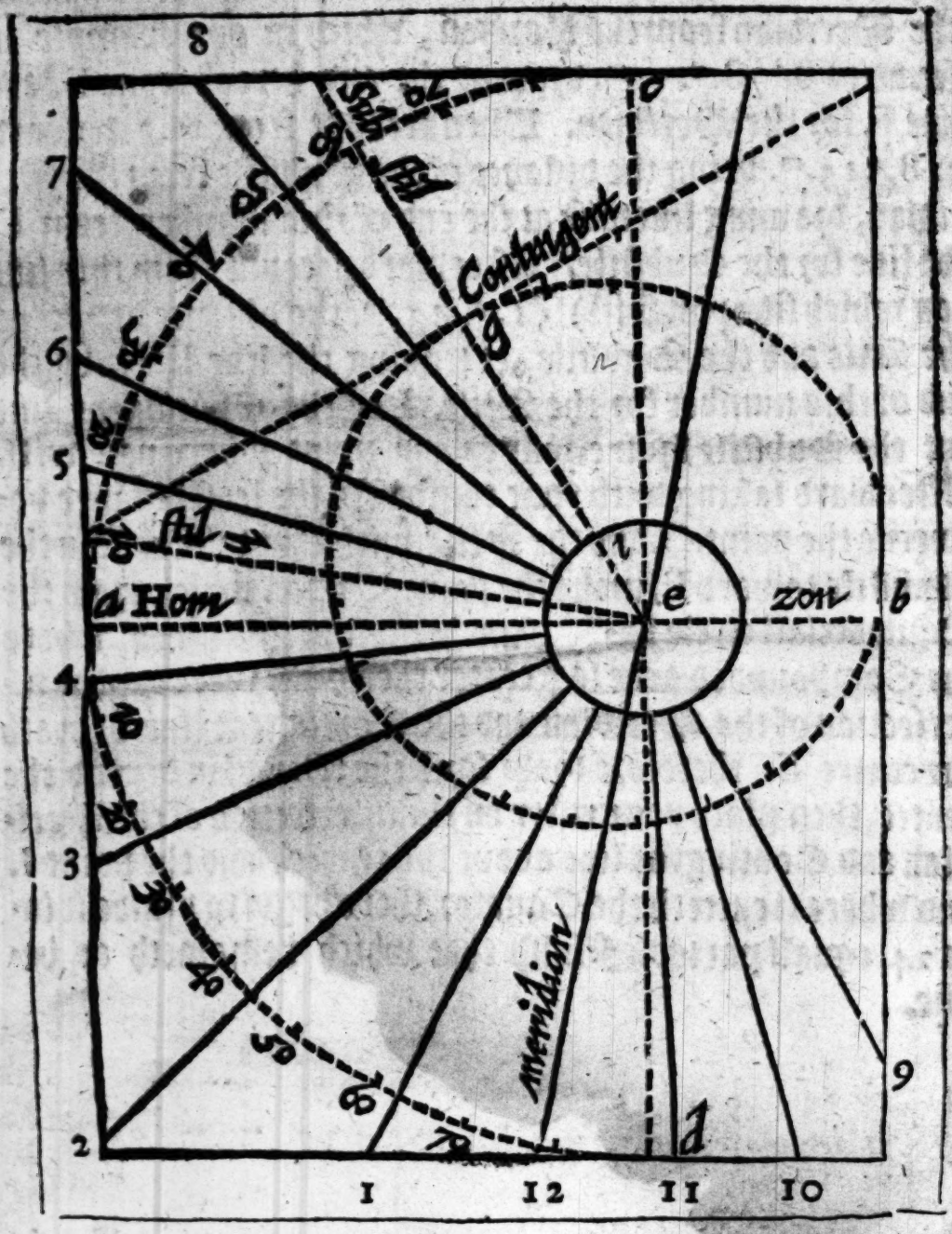
First as before, draw a line A. B. parallele to the Horizon.

zon. Make another C. D. squire-wise to the former. Draw two quadrants at the least C.A. D. dividing each of them into 90.d. number therein from A. toward D. the distance of the Meridian from the Horizon, which in our example is found to be 78.d. 2.m. draw at the end hereof from E. the line F. for the Meridian. Then account from this vpward 138.d.15.m. being the distance of the Substile from the Meridian, drawing likewise at the end of this number from E. the line for the Substile. Afterward account from this line (on which side you will) 51.d. 43.m. the distance betweene the Stile and the Substile, extending the line E. H. by the end of this number for the Stile. Let the Contingent line cut the Substile squire-wise in any point where you will. Afterward taking with your compasses the least distance betweene the point G. and the Stile, with that widenesse in the Substile toward E. make the point I. vpon which draw the Equinoctiall circle by G. And because in this kinde, where the Compounded arke is greater then 90.d. there is none intersection of the Meridian and the Contingent line beneath the centre E. therefore draw forth the Meridian beyond the centre, then place your ruler on the intersection of the Meridian and Contingent line aboue the centre, and the point I. and where it cutteth the Equator, there begin to diuide it into 24. equall partes. Finish that which remaineth as before.



A North

A North reclining declining.



The making of a South Inclining direct Diall.

CHAP. 16.

If the inclination of the plat be lesse then the Elevation of the Pole, take that from this, accounting the remainder for the Elevation of the Pole. And with this number as if it were

where the Eleuation of the Pole make a Diall like to the South erect direct, and it shall be fit for your plat.

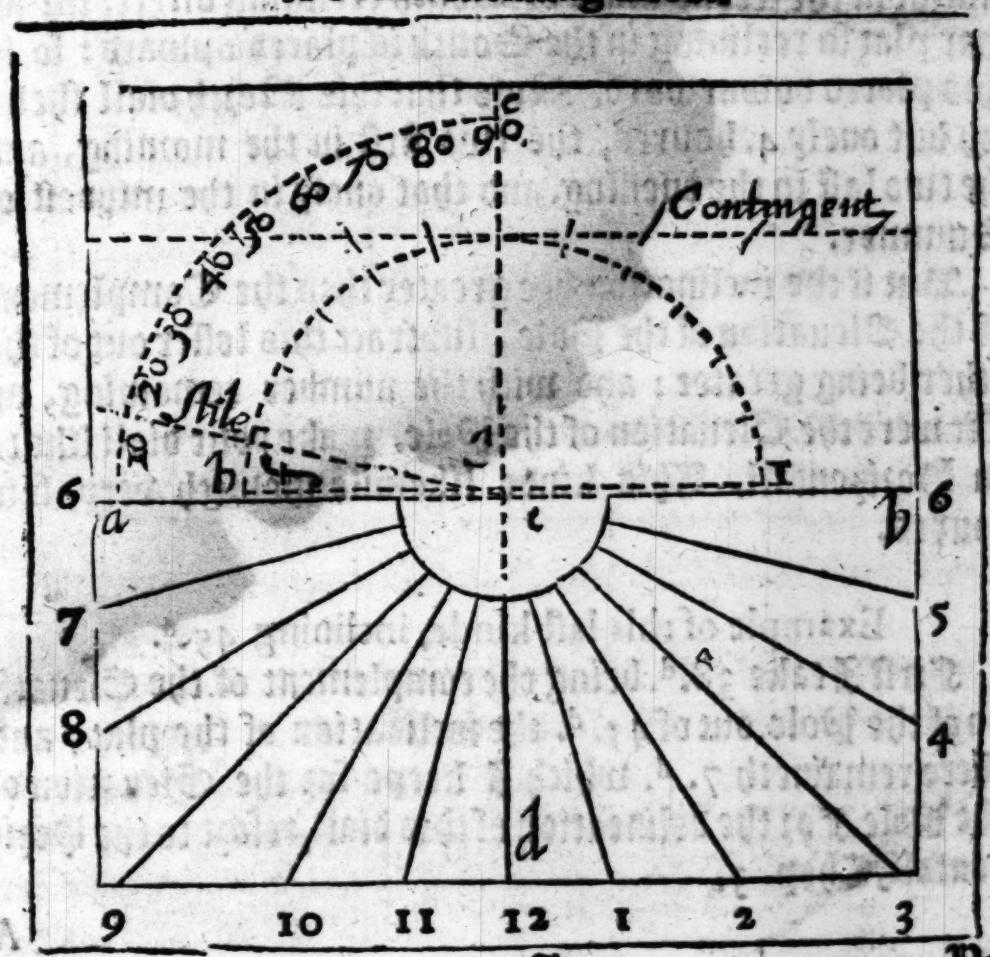
But if the Inclination of the plat be equall with the Eleuation of the Pole, make your Diall altogether like to the North reclining direct, whose reclination likewise is equall to the Eleuation of the Pole. They differ onely herein, that this is placed downeward to the earth, and that vpward.

But if the Inclination of the plat be greater then the Eleuation of the Pole, substract this from that, and with the number remaining, as if it were the Eleuation of the Pole, make your Diall like to the North erect direct.

Example of this kinde inclining 65.d.

Substract 52.d. the Eleuation of the Pole, out of 65.d. being the Inclination of the plat, and the remainder 13.d. account the Eleuation of the Pole. For the delineation hereof, resort to the North erect Diall, Chap. 5.

A South Inclining direct.



A You

You see in this Figure, that all the lines for the houres are drawne opposite from the Contingent line, beyond the centre E. In like manner must you doe in the delineation of all such, which incline more then the elevation of the Pole.

Let the Stile in this kinde bee placed directly ouer the Meridian, with so great an angle as D. E. F. is, &c.

The making of a North inclining direct Diall.

Chap. 17.

IF the Inclination of the plat be lesse then ỹ complement of the Elevation of the Pole, adde the inclination to the Elevation: and with that number, as if it were the Elevation of the Pole, make a North erect direct diall for your plat.

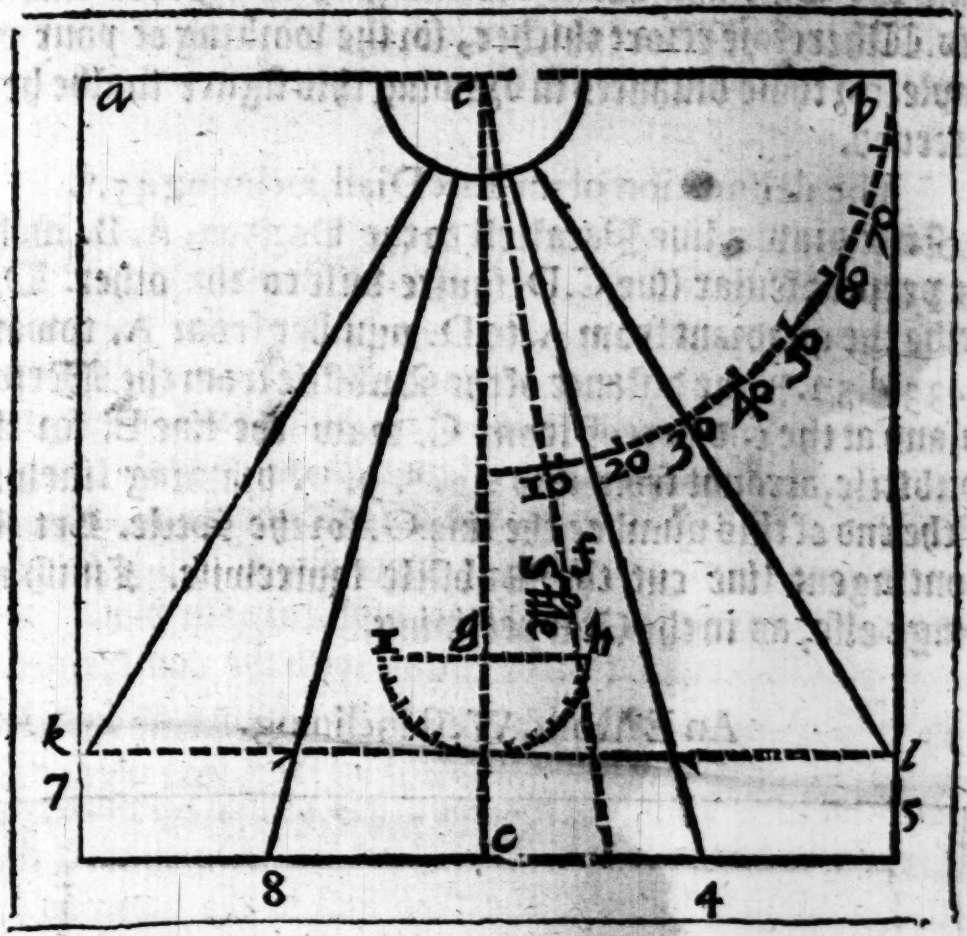
But if the inclination be equall with the complement of the Elevation of the Pole, then make a Diall as you were taught in the *second kinde of South* reclining direct: for as that plat so reclining in the South is placed vpward: so is this placed downeward. Note that this North diall sheweth but onely 4. houres, the two first in the morning, and the two last in the euening, and that onely in the middest of Summer.

But if the inclination bee greater then the Complement of the Elevation of the Pole, subtract this lesser out of the other being greater: and with the number remaining, as if it were the Elevation of the Pole, make your diall like to an Horizontall. This kinde likewise sheweth very few houres.

Example of this last kinde, inclining 45.d.

First I take 38.d. being the complement of the Elevation of the Pole, out of 45.d. the inclination of the plat, and there remaineth 7.d. which I keepe for the Elevation of the Pole. For the delineation of this diall, resort to the Horizontall, Chap. 3.

A North inclining Direct.



The making of the East and West inclining Dials.

Chap. 18.

Multiply the Sine of the Eleuation of the Pole by the Sine of the Inclination of the plat, diuiding the product by the whole Sine: the quotient arke shalbe the distance of the Stile from the Substile.

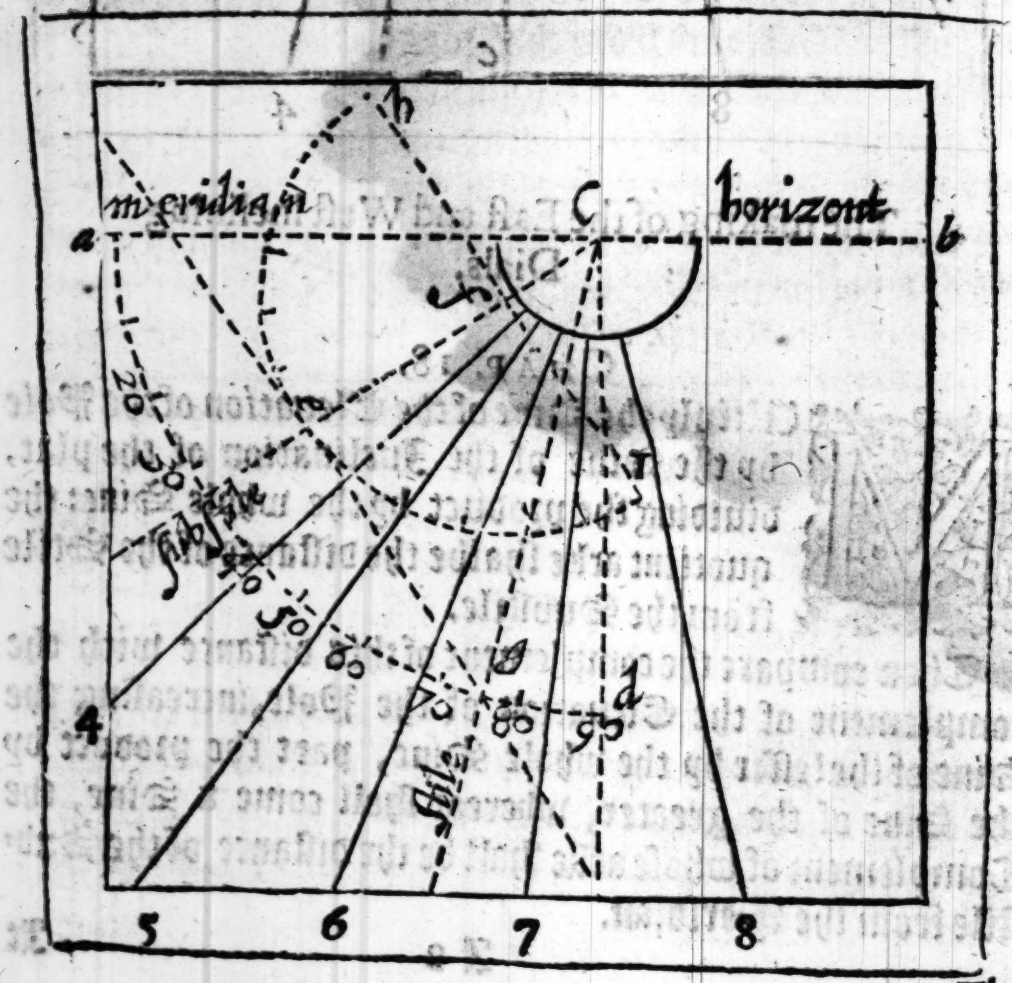
Then compare the complement of this distance with the complement of the Eleuation of the Pole, increasing the Sine of the lesser by the whole Sine, part the product by the Sine of the greater, whereof shall come a Sine, the Complement of whose arke shall be the distance of the Substile from the Meridian.

It shall not be necessary to shew any example hereof, because the East and West reclining be altogether like to this. Wherefore resort thither, for the working of your example, for those distances in drawing this figure shalbe here observed.

The delineation of an East Diall, inclining 45.d.

First draw a line Parallell to the Horizon, A. B. make the perpendicular line C.D, squire-wise to the other. Describe the quadrant from A. to D. number from A. toward D. 33.d.52.m. the distance of the Substile from the Meridian, and at the end hereof from C. draw the line E. for the Substile, account from this 42.d.9.m. drawing likewise at the end of this number the line G. for the Stile. Let the Contingent line cut the Substile squirewise. Finish all things else, as in the East reclining.

An East and West inclining.



The

The making of a South inclining declining Diall.

Chap. 19.



First, multiply the Sine of the Declination, by the Sine of the complement of the inclination, parting the product by the whole Sine. The quotient Sine shall yeeld an arke, whose complement shall be named the complement repeated.

Then increase the Sine of the Complement of the Declination by the whole Sine: and the product diuide by the Sine of the Complement repeated: whereof shall come a Sine, whose arke is the distance of the Meridian from the Horizon.

Afterward, this Sine being multiplied by the Sine of the Complement of the inclination, and the product parted by the whole Sine: the arke of the quotient Sine shall bee the Eleuation of the Meridian. Which arke you must adde to the Eleuation of the Pole. And if the totall number bee lesse then 90.d. it shall be named the Doubtfull Arke. But if it be greater then 90.d. take it from 180, and let the remainder be called the Doubtfull Arke.

This done, augment the Sine of the Complement repeated, by the Sine of the Doubtfull Arke: and the product arising thereof being diuided by the whole Sine, the quotient arke shall be the distance of the Stile from the Substile.

Now compare the Complement of this distance, with the Complement of the Doubtfull Arke, multiplying the Sine of the lesser, by the whole Sine, diuiding the product by the Sine of the greater: the arke of the quotient Sine com-

comming thereof shall be the distance of the Substile from the Meridian.

But note, if the doubtfull ark be found without subtraction from 180, (which is if it be lesse then 90.d.) then you must subtract the distance of the Substile from the Meridian out of 180, and the number remaining, shall be the true distance of the Meridian from the Substile.

Marke this likewise, if the doubtfull arke be equall 90. degrees, let the Complement repeated bee the distance of the Stile from the Substile: then shall there bee iust 90.d. for the space betweene the Substile and the Meridian, as before is taught in the North declining reclining, whither you may resort for the working hereof. Here it shall bee sufficient to shew two examples, with the delineation of their figures: the one, where the doubtfull arke is subtracted from 180.d. and the other, where there is no subtraction hereof, because it is lesse then 90. degrees.

Example of a South Diall { Inclining 45. degrees. / Declining 45. degrees.

Forasmuch as this is altogether like to the North reclining 45.d. declining 45.d. whither you may resort: I will omit the working of the former part of this example, vntill I come to the finding out of the distance of the Substile from the Meridian. The former part of this example you may find to be thus wrought in the North reclining declining:

1 First, the complement repeated 60.d.

2 Then, the distance of the Meridian from the Horizon 54.d. 44.m.

3 Next, the Elevation of the Meridian 35.d. 16.m.

4 The compounded arke there, which we call the doubtfull arke here, 87.d. 16.m.

5 The distance of the Stile from the Substile 59.d. 54.m.

6 Last, the distance of the Substile from the Meridian 84.d. 33.m.

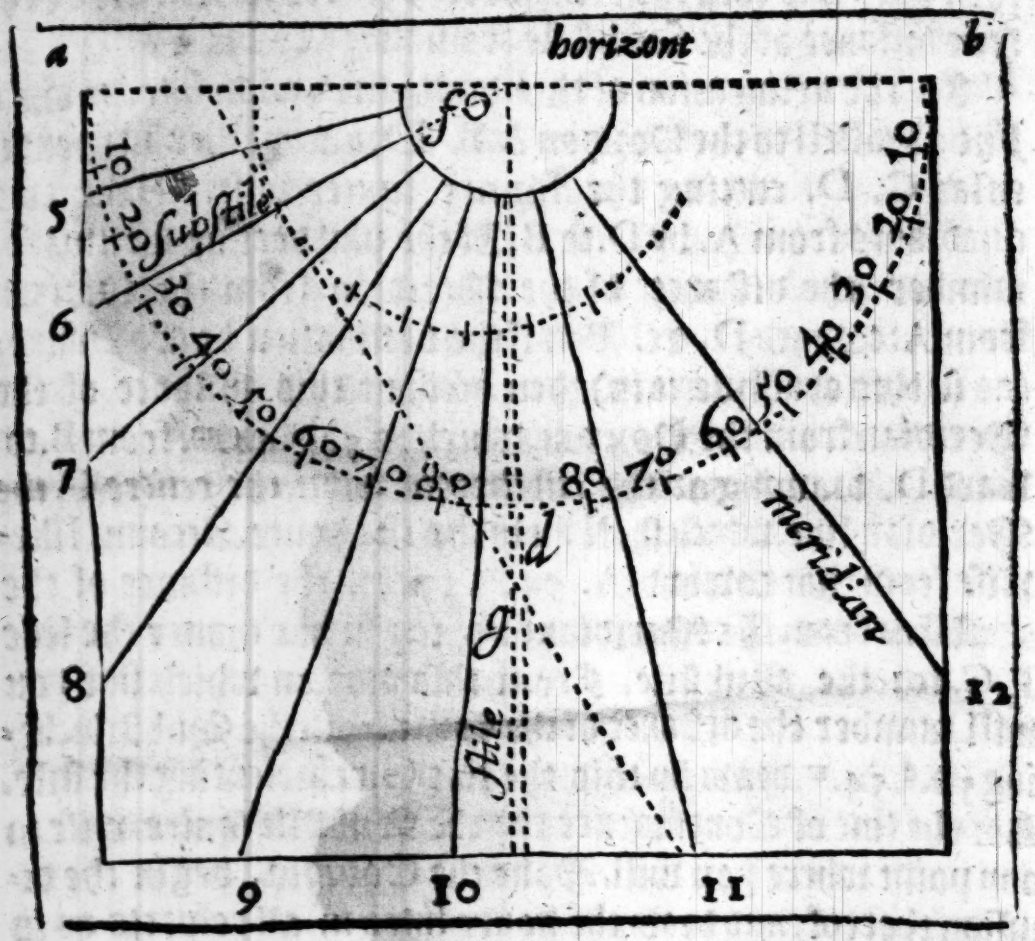
But

But here (as before is taught) you must subtract this distance from 180. d. because the doubtfull arke was lesse then 90.d. and then the remainder 95. d. 27. m. shall be the true distance of the Substile from the Meridian.

In the delineation of this diall, first, as before, make a line parallell to the Horizon A.B. Draw another perpendicular C. D. cutting the former squire-wise. Make two quadrants from A. by D. to B. If the plat decline westward, number the distance of the Meridian from the Horizon from A. toward D. &c. But if the declination be Eastward, (as in this example it is) then account this distance of the Meridian from the Horizon, which is 54.d.44.m. from B. toward D. drawing at the end hereof from the centre C. the Meridian line, which shall shew the 12. houre. Account likewise from that toward A. 95. d. 27. m. the distance of the Substile from the Meridian: making in like maner the line E.C. for the Substile. From this line on which side you will, number the distance of the Stile from the Substile, being 59.d.54.m. draw by this the line G. representing the stile. Let the line of Contingence cut the Substile squire-wise in any point where you will. Make the Equator, begin the division thereof, and draw the houre lines in all respects as in the North reclining 21.d.30.m. declining 30.d. Chap. 15.

A South

A South declining inclining Diall.



The second example of a South Diall { Inclining 33.d.4m. / Declining 31.d. } Where the doutfull arke is subtracted from 180.

First 51503 the Sine of the Declination being multiplied, by 83227 the Sine of the Complement of the inclination: and the product 4286440181 diuided by the whole Sine: the arke of the quotient is 25.d.23.m. The complement whereof being 64.d.37.m. is the complement repeated.

Then I increase the Sine of the Complement of the declination, which is 85716, by the whole Sine, and I part the product 8571600000, by 90346. the Sine of the Complement repeated. The quotient 94875 yeeldeth an arke 71.d.35.m.

71.d.35.m. which is ỹ distance of ỹ Meridian frō the Horizō.

Againe, I multiply this Sine 94875, by the Sine of the Complement of the Inclination being 83227, and the product 7895961425 arising thereof, I diuide by the whole Sine. The arke of the quotient is 52.d.9.m. which is the Eleuation of the Meridian.

Now this being added to the Eleuation of the Pole 52.d. and the totall number 104.d.9.m. taken from 180 there remayneth 75.d.51.m. which is the doubtfull arke.

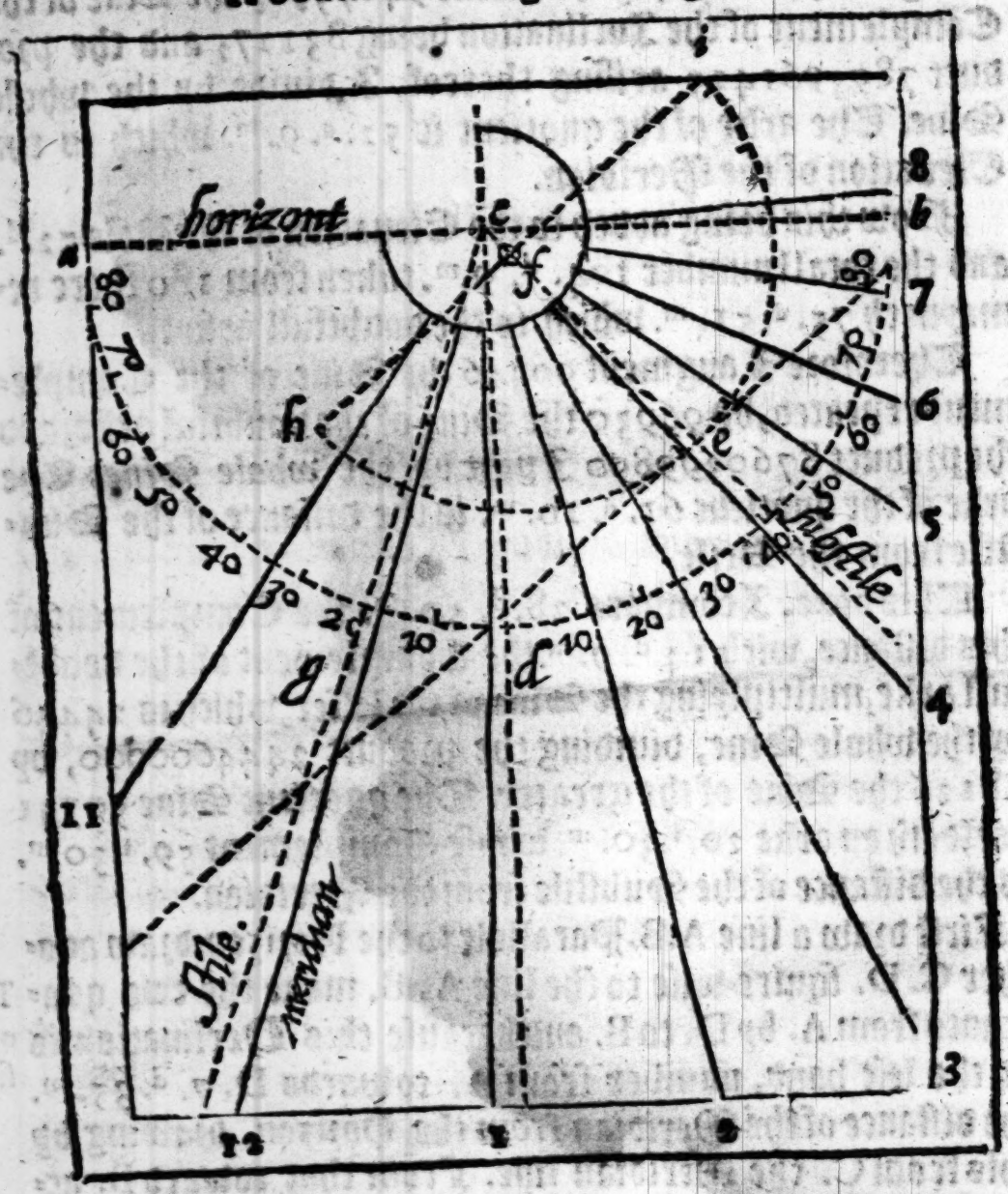
Therefore I augment 90346 the Sine of the Complement repeated, by 96930 the Sine of the doubtful arke, and the product 8760399890 I part by the whole Sine. The arke of the quotient 61.d.10.m. is the distance of the Substile from the Stile.

This done, I compare 28.d.50.m. the Complement of this distance, with 14.d.9.m. the Complement of the doubtfull arke, multiplying the Sine of the lesser, which is 24446 by the whole Sine, diuiding the product 2444600000, by 48226 the Sine of the greater. The quotient Sine 50741 yeelds ath an arke 30.d.30.m. whose Complement 59.d.30.m. is the distance of the Substile from the Meridian.

First draw a line A.B. Parallele to the Horizon: draw another C. D. squire-wise to the line A. B. make the two quadrants from A. by D. to B. and because this Declination is on the left hand, number from A. towards D. 7.d.35.m. the distance of the Meridian from the Horizon, drawing by this from C. the Meridian line. From that toward B. account 59.d.30.m. the distance of the Substile from the Meridian, making in like manner at the ende of this number from C. the Substile line E. Againe from this forward (if you can, or else backward) number the distance of the Stile from the Substile, which is 61.d.10.m. Draw likewise by this from C. the line G. for the Stile. Let the Contingent cut ỹ Substile squire-wise in any place, where you will, &c. The making of the reclining declining Dials before, shall teach you the finishing of this likewise.

The delineation of the figure.

A South declining inclining.



The making of a North inclining declining Diall.

CHAP. 20.

THe working of this kinde is altogether like the South reclining declining diall.

First therefore multiply the Sine of the Declination, by the Sine of the Complement of the inclination, diuiding the product by the whole Sine. The quotient shall giue an arke: whose Complement

plement shall bee named the Complement repeated.

Then augment the Sine of the Complement of the Declination by the whole Sine, and the product part by the Sine of the Complement repeated. Whereof will come a quotient Sine: whose arke shall be the distance of that which is as it were the Meridian from the Horizon.

For the finding out of the Eleuation of the Meridian, because it may be done two sundry waies, I will set them downe both, referring the choyce to your selfe.

Compare the Complement of the arke last found out, with the Declination of the plat, multiplying the Sine of the lesser, by the whole Sine: and diuiding the product by the Sine of the greater. The quotient Sine shall yeeld an arke whose Complement shall be the Eleuation of the Meridian.

Or multiply the Sine of the arke last found out by the Sine of the Complement of the inclination, part the product by the whole Sine: and the arke of the quotient Sine shall be the Eleuation of the Meridian.

Now comparing the Eleuation of the Pole with the Eleuation of the Meridian, subtract the lesser from the greater, retaining the number remaining, which shall be called the difference kept.

Afterward increase the Sine of the difference kept, by the Sine of the Complement repeated, and diuide the product by the whole Sine. The quotient arising of this diuision shall giue an arke, which shall be the distance betweene the Stile and the Substile.

To conclude, the Complement of this distance being compared with the Complement of the difference kept, multiply the Sine of the lesser by the whole Sine, and part the product by the Sine of the greater. The Complement of the arke of the quotient Sine, shall bee the distance of the Substile from the Meridian.

But note, if the Eleuation of the Meridian, and the Eleuation of the Pole be found equall, make an Equinoctiall

Diall, as before you were taught in the Meridionall reclining declining: for there is no difference, but only that this is placed downward, and the South vpward.

There be of this North, as of the South reclining declining, three sundry kinds of Dials, as by the examples and figures following you may perceiue.

First example. Example of a North Diall { Inclining 20 d. / Declining 30 d.

First, I multiply 50000 the Sine of the declination, by 93969 the Sine of the Complement of the inclination, and the product thereof 4698450000, I diuide by the whole Sine 100000, and the quotient Sine 46984 yeeldeth an arke 28 d. 2 m. whose Complement 61 d. 58 m. is the Complement repeated.

Then I augment the Sine of the Complement of the declination, which is 86602 by the whole Sine, parting the product 8660200000. by 88267 the Sine of the Complement repeated: the quotient is 98113. The arke thereof being 78 d. 51 m. is ỹ distance of the Meridian frō the horizon.

Two waies in working the example, for the two precepts of the finding out the Eleuation of the Meridian.

Now in comparing the Complement of the arke last found out, with the declination of the plat: I find the Complement of the arke least. Wherfore I multiply ỹ Sine therof being 19337 by the whole Sine: and the product 1933700000, I diuide by 50000 the Sine of the greater. The quotient 38673 giueth an arke 22 d. 46 m. whose Complement 67 d. 14 m. is the Eleuation of the Meridian.

Both these tend to one end.

Or multiplie 98112 the Sine of the arke last found out, by the Sine of the Complement of the inclination, which is 93969: and the product 9219566568 part by the whole Sine. The quotient shall bee 92192, whose arke 67 degrees 14 minutes is the Eleuation of the Meridian.

This done, I compare the Eleuation of the Meridian 67 d. 14 m. with the Eleuation of the Pole 52 d. subtracting the lesser from the greater, and there remaineth 15 d. 14 m. which is the difference kept.

Then

Then I multiply 26275 the Sine of the difference kept, by 88267 the Sine of the Complement repeated: parting the product 2318455682, by the whole Sine. The arke 11 d. 47 m. of the quotient Sine 23184, is the distance of the Stile from the Substile.

Now the Complement of this distance being 76 d. 36 m. compared with 74 d. 47 m. the Complement of the difference kept, I encrease 96494 the Sine of the lesser, by the whole Sine, and the product thereof 9649400000, I distribute by 97277 the Sine of the greater. And the quotient is 99191, whole arke is 82 d. 43 m. The complement whereof being 7 d. 17 m. is the distance of the Substile from the Meridian.

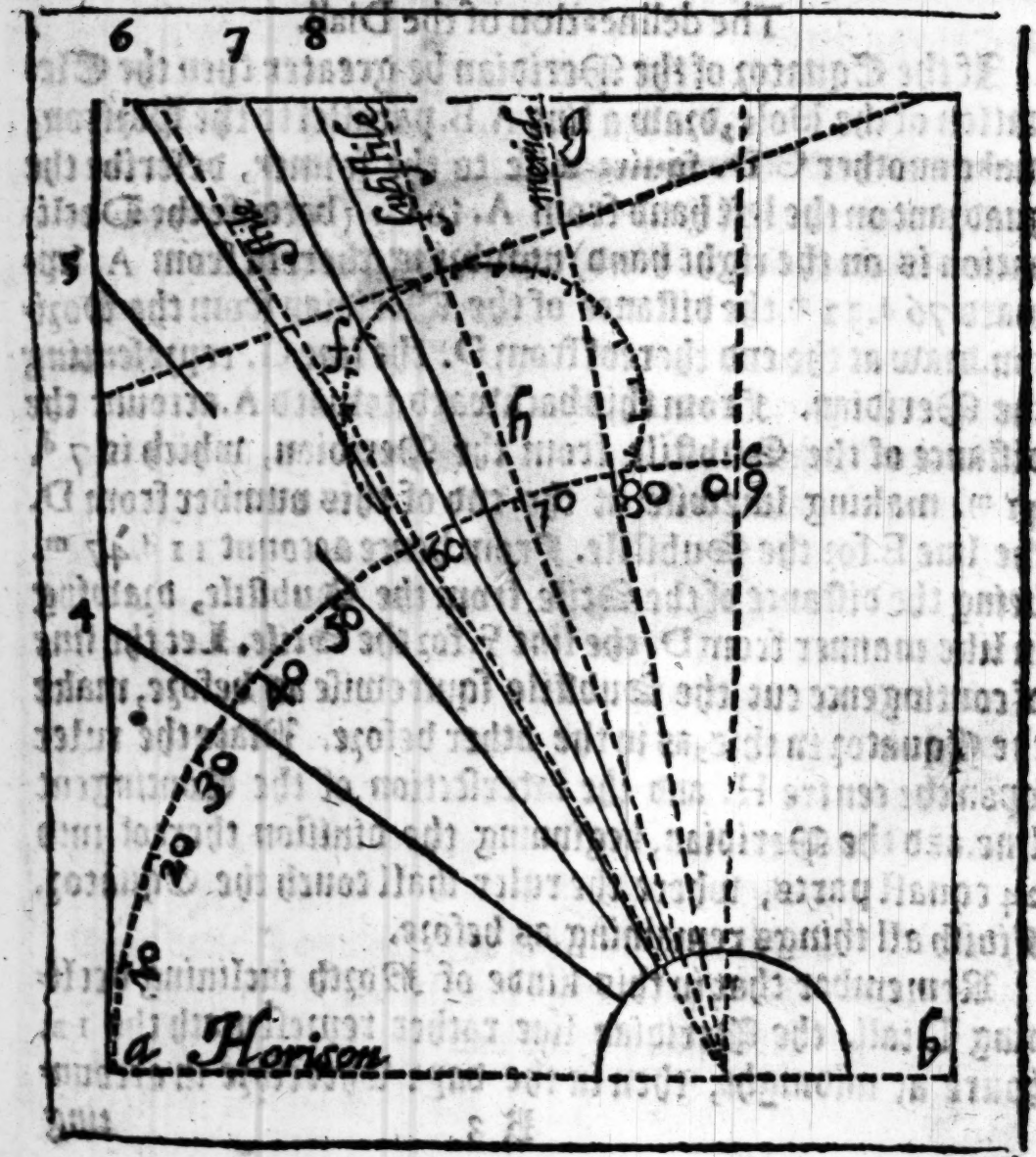
The delineation of the Diall.

If the Equator of the Meridian be greater then the Elevation of the Pole, draw a line A.B. parallel to the Horizon, make another C.D. squire-wise to the former, describe the quadrant on the left hand from A. to C. (because the Declination is on the right hand) numbring therein from A. upwards 76 d. 32 m. the distance of the Meridian from the Horizon, draw at the end thereof from D. the line G. representing the Meridian. From this backward, toward A. account the distance of the Substile from the Meridian, which is 7 d. 41 m. making likewise at the end of this number from D. the line E. for the Substile. From hence account 11 d. 47 m. being the distance of the Stile from the Substile, drawing in like manner from D. the line F. for the Stile. Let the line of contingence cut the Substile squirewise as before, make the Equator in this, as in the other before. Place the ruler upon the centre H. and the intersection of the Contingent line, and the Meridian, beginning the division thereof into 24 equall parts, where the ruler shall touch the Equator. Finish all things remaining, as before.

Remember that in this kinde of North inclining declining Diall, the Meridian line rather representeth the 12. houre at midnight, then in the day: wherefore in accounting

ting the houre lines, let the Meridian be alwaies for the 12. houre in the night. And then if your plat decline Westward, account backward as it were 11. 10. 9. which houres with the 12. you may omit in the delineation of your Dial, because they haue no vse in our Elevation. But account forward 8,7,6,5,4, &c. so many as you thinke shall be necessary, for some declination will receiue more, then other will: the greater the more, the lesser the fewer houres. But if the declination of your plat be Eastward, then account from the Meridian line forward 1,2,3,4, &c. so many as shall be needfull, omitting likewise the first three, &c.

A North inclining declining.

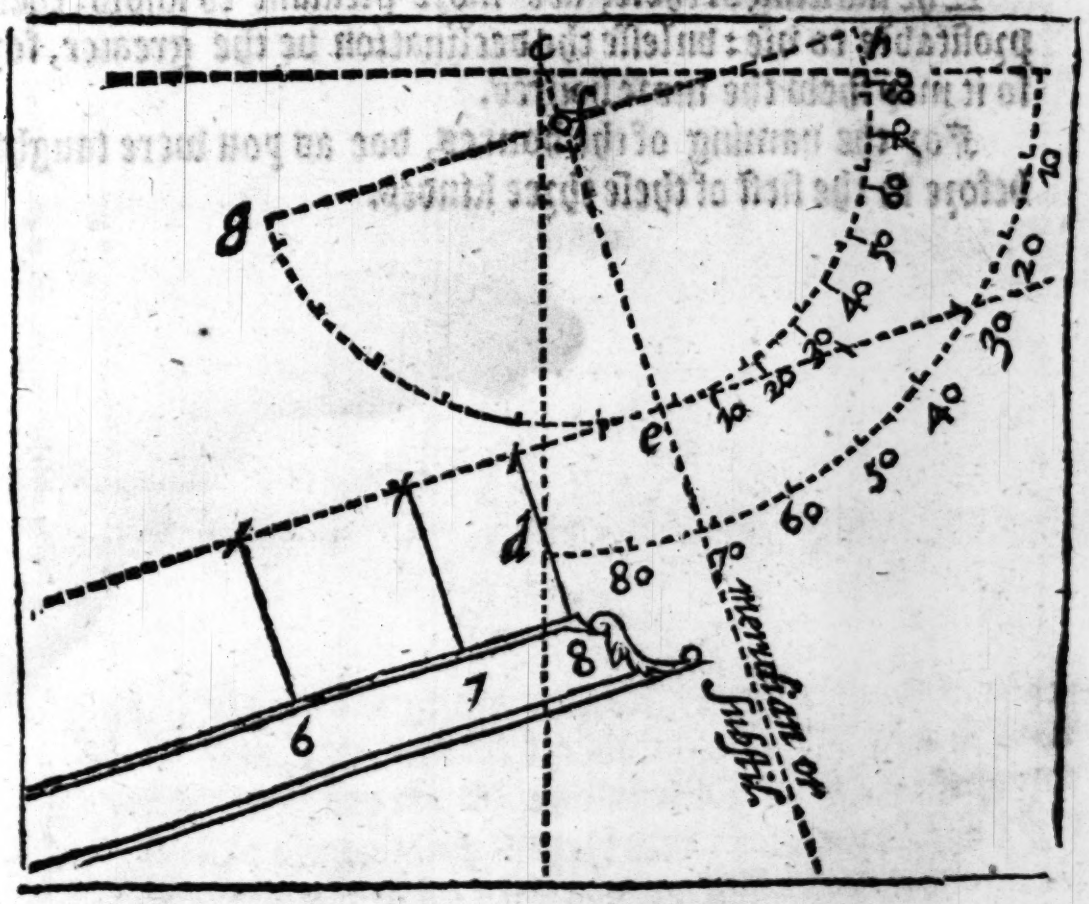


The

The second kinde.

But if the Elevation of the Meridian, and the Elevation of the Pole be equall, the making of the Diall differeth from the other before. For an example hereof, and the drawing of the Figure, resort to the South reclining 33. d. 30. m. declining 32. d. for these are both alike, onely remember here that if this decline Eastward, make the quadrant likewise on the East side, &c. But if the plat decline toward the West, make the quadrant Westward (as in the figure following) finishing all things else as hereyou see done. Observe the same order in naming the houre lines which I taught you before.

A North inclining declining.



The

The Art of Dialling.

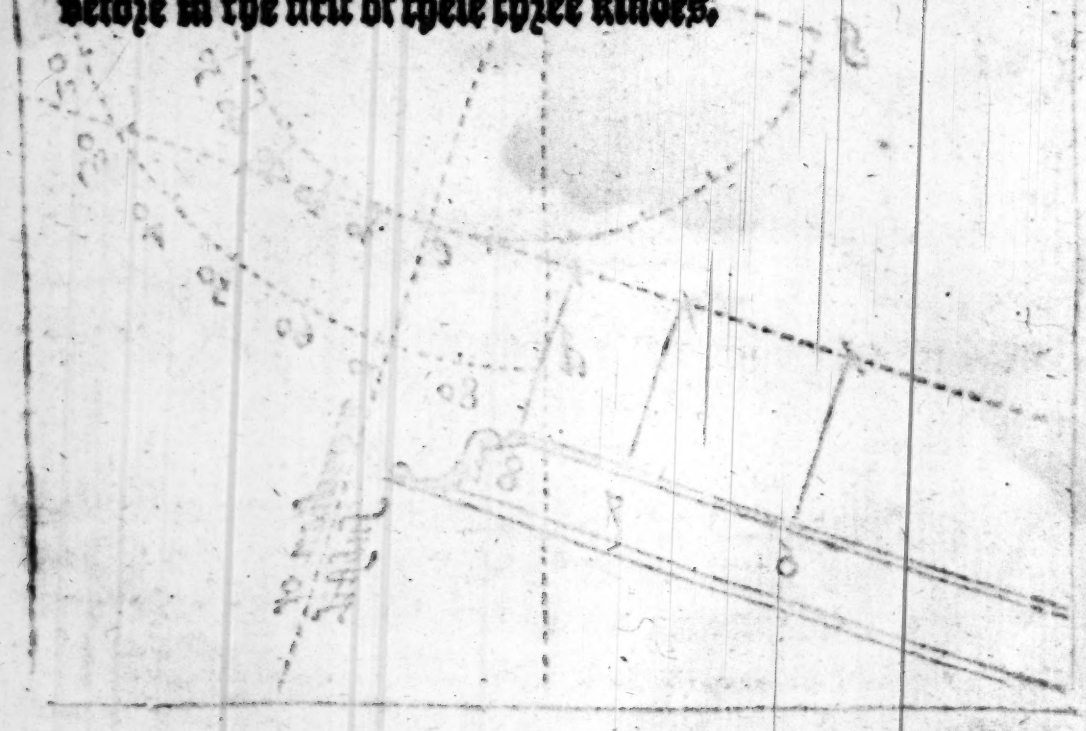
The Third Example of a North Diall. { Inclining 45. d. / Declining 45. d.

If the Elevation of the Meridian be lesser then the Elevation of the Pole, make your Diall thus.

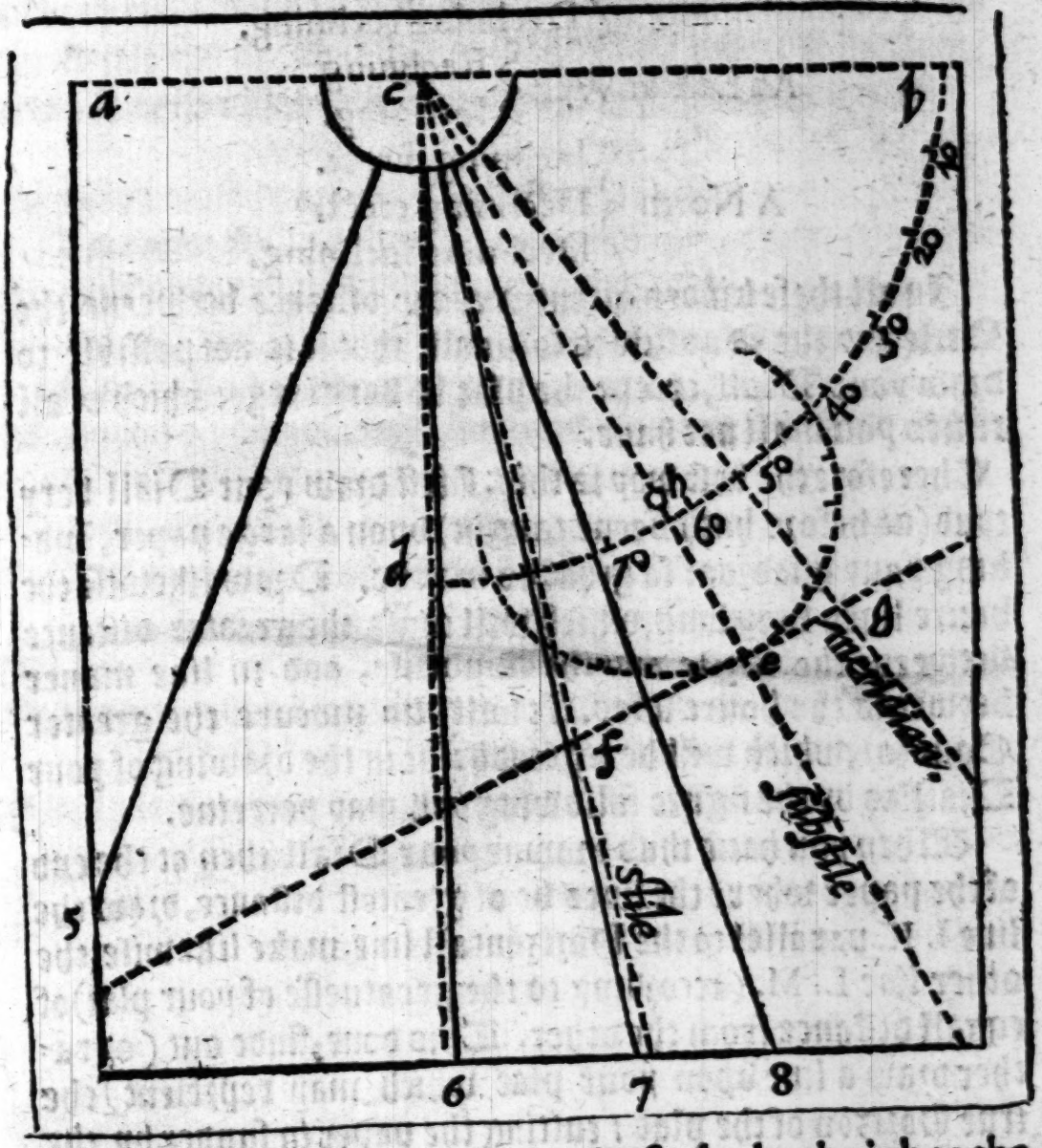
For the working of the example, and the delineation of the figure, resort to the South reclining 45. d. declining 45. d. for that agreeth with this, except onely that in this, the Stile is placed downeward, and sheweth but few houres, and those likewise are drawne downeward: but in the other the Stile standeth upward, shewing many houres, and those likewise for the most part are drawne upward. Marke also in this kinde, if your plat decline Westward, draw the quadrant on the Westside, but if the declination be Eastward, make the Quadrant on the Eastside, &c.

The making of these, are more pleasant to know, then profitable to use: unlesse the declination be the greater, for so it may shew the more houres.

For the naming of the houres, doe as you were taught before in the first of these three kindes.



A North Declining Inclining.



The delineation of those Dials, whose plat lyeth nigh to the Elevation of the Pole.

CHAP. 21.

WHen as the declination and reclination, or declination, and inclination, shall cause the plat of your Diall to lie nigh to the Elevation of ỹ Pole, then the houre lines must be drawne very long, to make ỹ distances somwhat large, so that they may be discerned one from another. And common-

commonly these following be such as here we meane.

A South { Reclining direct. / Declining erect. / Declining reclining.

An East or West { Reclining. / Inclining.

A North { Inclining direct. / Declining erect. / Declining inclining.

In all these kindes oftentimes the distance betweene the Stile and the Substile is so small, that it is not possible to draw your Diall, except the plat be very large: which at all times you shall not haue.

Therefore the best way is this. First draw your Diall very true (as before hath beene taught) vpon a large paper, making your quadrant so great as may be. Draw likewise the houre lines very long, which will cause the greater distance betweene the Stile and the Substile, and in like maner betweene the houre lines. It will also procure the greater Equator, which will be a great helpe in the drawing of your Diall, as by the figure following you may perceiue.

When you haue thus drawne your Diall, then at the end of the paper where the lines be of greatest distance, draw the line I. K. parallel to the Horizontall line, make likewise the other line L. M. (according to the greatnesse of your plat) of equall distance from the other. This done, finde out (or rather draw a line vpon your plat which may represent) the true Horizon of the plat: cutting the paper in sunder by the line I.K. and the line L.M. placing it vpon your plat very plain, so that one of the edges may be parallel to the Horizon. Then make markes vpon the plat at both ends of all the houre lines, drawing by those markes, the lines for the howres. Draw likewise light lines vpon the plat for the Stile and the Substile, easily to be extinguished, as you did vpon the paper.

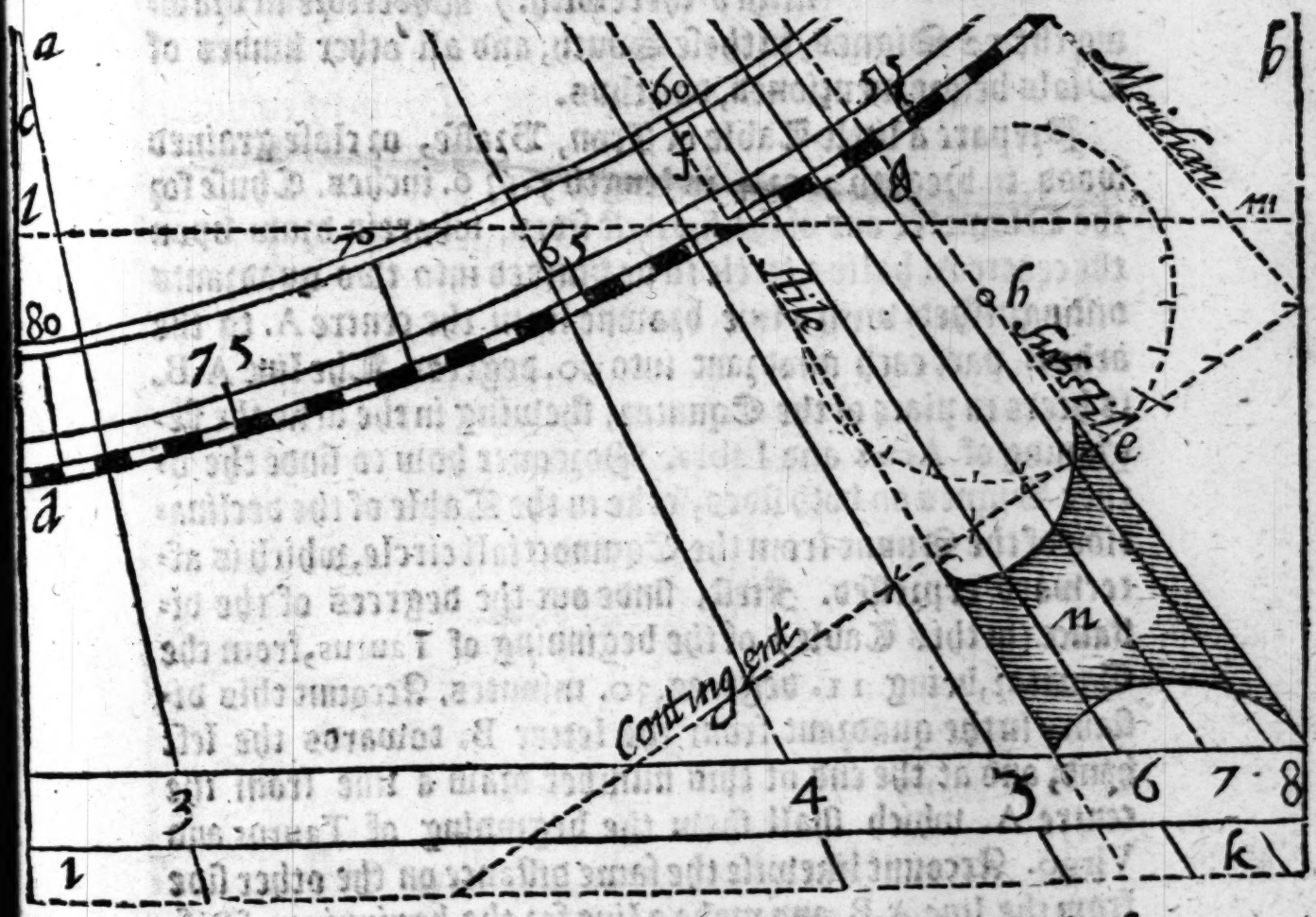
Let the Stile N. be fastened ouer the Substile, as you haue

been taught in the East, and West, or Equinoctiall Dialls.

But here note, that the Stile must not be of equall height at both ends. But let it be so high, as the distance betweene the Stile and the Substile is in the place where it standeth, as in the examples following you may plainely perceiue.

A North Diall.

Declining Westward ——— 65.d.
Inclining ——— 22 d. 30. m.
Distance of the Meridian from the horizon - 50.d. 50.m.
Distance of the Substile and the Meridian 6.d. 35.m.
Distance of the Stile and Substile ——— 4.d. 15.m.
Elevation of the Pole ——— 52.d.



Hitherto we haue taught the delineation of all kinds of Dials, which are to be made vpon any plaine plat or superficies: now followeth the garnishing of them, with the 12. Signes, and the houres vnequall.

How to draw the 12. Signes in all kindes of Dials before mentioned.

Chap. 22.

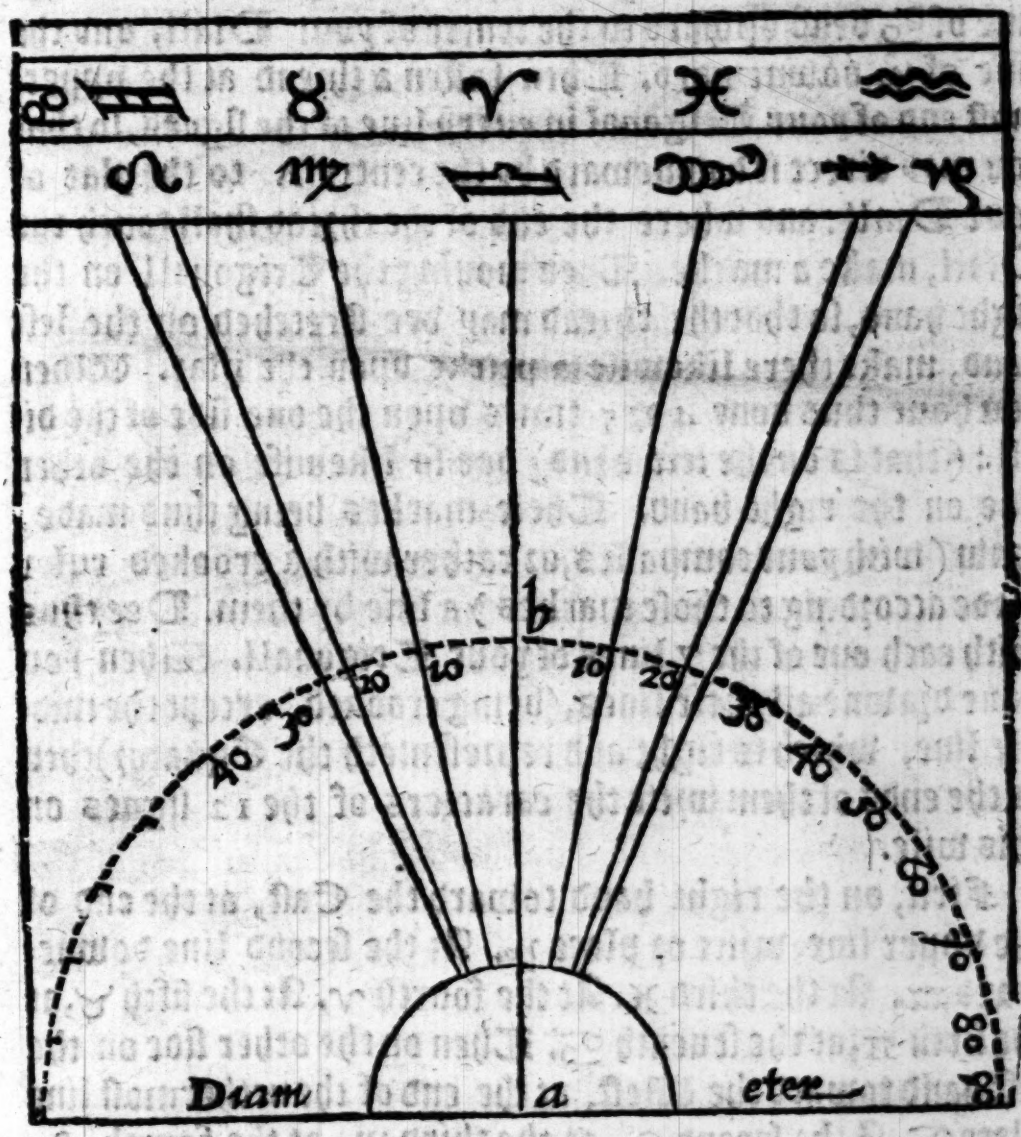
Forasmuch as sometime the 12 signes of the Zodiake are placed in Sunne Dials, to know in what signe the Sunne is at any time (which albeit any kinde will receiue, yet most commonly the verticall directly oppolite to the South are garnished therewith:) Therefore in drawing the 12 Signes, in these South, and all other kindes of Dials before meutioned, doe thus.

Prepare a little Table of Iron, Brasse, or close grained wood, in breadth 3. or 4. *in length* 5. or 6. inches. Chuse for the Diameter one of the shortest sides, wherein draw vpon the centre A. halfe a circle to be diuided into two quadrants distinguished with a line drawne from the centre A. to the arke B. part each quadrant into 90. degrees. The line A.B. is heere in place of the Equator, shewing in the arke the beginning of Aries and Libra. Moreouer how to finde the other Signes on both sides, seeke in the Table of the declination of the Sunne from the Equinoctiall circle, which is afterward expressed. First, finde out the degrees of the distance (in this Table) of the beginning of Taurus, from the Equator, being 11. degrees, 30. minutes. Account this distance in the quadrant from the letter B. towards the left hand, and at the end of this number draw a line from the centre A. which shall shew the beginning of Taurus and Virgo. Account likewise the same distance on the other side from the line A.B. and make a line for the beginning of Pisces and Scorpius. Againe in the 20.^{d}.12.^{m}. from the line A. B. you shall haue the beginning of Gemini and Leo: and so many degrees and minutes on the other side, the beginning

of

of Aquarius and Sagittarius. To conclude on both sides in the 23. degrees 30. minutes, there must be on the one part Cancer, and on the other Capricorne.

Afterward draw lines from the centre A. by every marke so long as your Table will receive: & at the end of these lines set the caracters of the 12 signes of the Zodiake be sired: as in the figure following you may see.



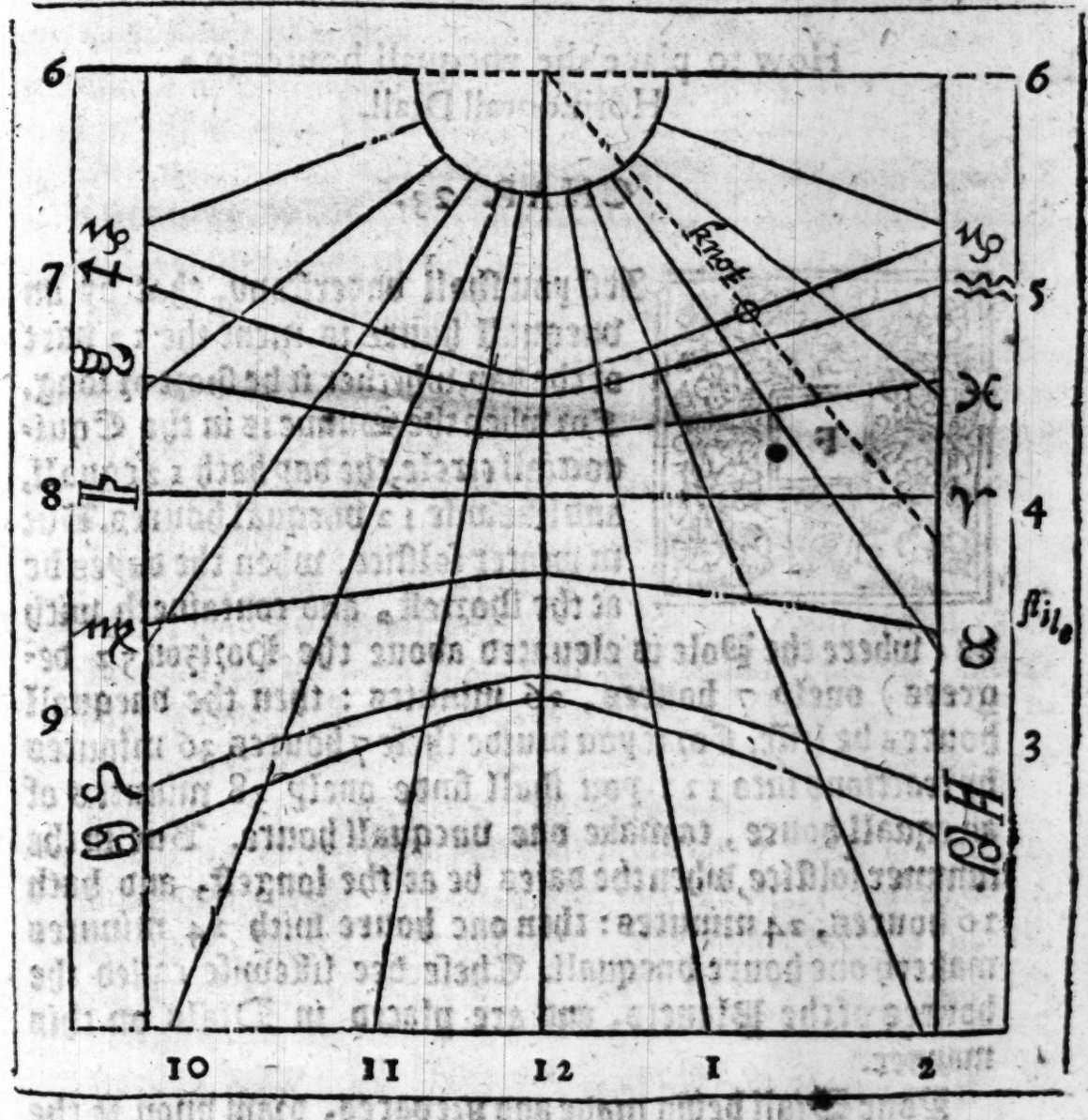
The vse of this Trigonall Instrument, in writing the 12 signes in Dials.

YOur Diall being made, and the Stile placed therein: take your Trigonall Instrument, and set it vpon the Stile, so that the whole Diameter thereof may stand plaine vpon the edge or vpper part, the centre A. of your Instrument alwaies remaining in one place of the Stile. Let the line of ♋ bend vpward to the centre of your Diall, and the line of ♑ downeward. Then fasten a thread at the vppermost end of your Trigonal in every line of the signes, so that you may direct it downeward by the centre A. to the plat of your Diall: and where the end of the thread shall touch the Diall, make a marke. Then mouing the Trigonall on the right hand, so that the thread may bee stretched on the left hand, make there likewise a pricke vpon the plat. When you haue thus done 4 or 5 times vpon the one side of the diall: (that is on the left hand) doe so likewise on the other side on the right hand. These markes being thus made, draw (with your compasses, or rather with a crooked ruler made according to those markes) a line by them. Doe thus with each one of the 7 lines of your Trigonall. When you haue drawne all these lines, (being crooked, except the middle line, which is right and representeth the Equator) then at the ends of them write the caracters of the 12 signes on this wise.

First, on the right hand toward the East, at the end of the vpper line, write or place ♑. At the second line downeward ♒. At the third ♓. At the fourth ♈. At the fifth ♉, at the sixth ♊, at the seuenth ♋. Then on the other side on the left hand toward the West, at the end of the nethermost line place ♋. At the second ♌, at the third ♍, at the fourth ♎, at the fifth ♏, at the sixth ♐. And finally againe at the vppermost set ♑.

This done, remember that in what place of the Stile the centre

centre A. of your Trigonall was placed, there fasten a small piece of yron or any such like thing, which may shew with the shaddowe thereof, the Signe which the Sunne shall bee in at any time: vnlesse the houre lines bee so short, that where the small piece of yron should bee placed, you may cut the Stile that the end thereof shall shew it. But the first is the most conuenient way for the vse thereof.



You may in like manner with this Instrument draw or place the 12 signes in Horizontall, East, West, and all other kindes of Dials, which before are recited: because the

difference

difference is nothing but in placing the 12 signes at the ends of the lines: the true doing whereof, you may easily perceiue by the course of the Sunne. For in the South Erect, when the Sunne occupieth Cancer, then is the line of ☽ furthest distant from the center of the Diall. But in the Horizontall Diall, the line of ☽ is next to the centre. Few words shall suffice for this matter: experience shall easily teach you herein.

How to place the vnequall houres in a Horizontall Diall.

CHAP. 23.



First you shall vnderstand, that by an vnequall houre is ment the 12 part of the day, whether it be short or long. For when the Sunne is in the Equinoctiall circle, the day hath 12 equall, and likewise 12 vnequal houres. But in winter solstice, when the dayes be at the shortest, and containeth with vs (where the Pole is eleuated aboue the Horizon 52 degrees) onely 7 houres, 36 minutes: then the vnequall houres be lesse. For if you diuide these 7 houres 36 minutes by fractions into 12: you shall finde onely 38 minutes of an equall houre, to make one vnequall houre. But in the summer solstice, when the daies be at the longest, and hath 16 houres, 24 minutes: then one houre with 24 minutes maketh one houre vnequall. These bee likewise called the houres of the Planets, and are placed in Dials on this manner.

Your Diall being made and prepared, draw vpon it the 12 signes of the Zodiacke (as you were taught before) so large as your plat will giue leaue, &c.

Note that alwaies the Meridian line, or 12 equall houre, is

is the 6 vnequall houre. Marke likewise, that when the Sunne entreth into the begining of ♈ and ♎, both the equall and vnequall houres be of like quantity. For the 7 equall houre in the morning is the first vnequall, and the 8 equall the 2 planetare houre, &c.

But in the Tropike of ♋ it is otherwise: for then the vnequall houres be greater then the equall. Therefore account how many houres and minutes is in the longest day for your Elevation, changing all the minutes of those houres into one totall summe. Then diuide this number by 12: and the quotient shall shew how many minutes of an equall maketh one vnequall houre. Example hereof: with vs the longest day is 16 houres, 24 minutes. Wherefore I multiply 60 which is the minutes of an equall houre, by 16, which is the summe of houres of the longest day, and the product ariseth to 960, whereunto I adde 24 minutes remaining, then the number shall be 984, which being diuided by 12, the quotient is 82. Wherefore I conclude that 82 m. of an equall, maketh one vnequall or planetare houre. Then to draw them in Dials, worke thus.

First, in the Tropike of ♋ diuide the space betweene each houre into 60 equall parts, but because those distances be so small, for the most part, that this cannot be done: therefore it shall suffice to diuide euery one of them into three equall parts. Then shall euery part conteine 20. m. and three of them 60. m. which is one equall houre.

When as therefore you will place the 7 vnequall houre, account from the Meridian line, or the houre, 4 parts and 2 minutes (which is 82 minutes) and make there a marke. Then place your ruler by this point or marke, and the intersection of the line of ♈ and ♎, and the first houre after noone: draw a line from one Tropike to another, that is from ♋ to ♑.

Then for the placing of the 8 vnequall houre, account from the 7 last made, 4 of the foresaid parts and two minutes; make there a marke, by which and the intersection of

the line of ♈ and ♎ and the line of the second houre after noone, the ruler being placed, draw a line, as before.

For the 9. account from the 8 last made, likewise 4 parts and two minutes, drawing a line as before. Doe in like maner for the drawing of all the other remaining: that is, for the 10, and 11. The 12 being the Sunne setting, shall neede no line.

As you haue finished the vnequall houres on this side for the afternoone, doe in like maner for those in the forenoone: accounting from the Meridian 4 parts and 2 m. of an equall houre, to each vnequall, drawing, as before, lines from one Tropicke to another.

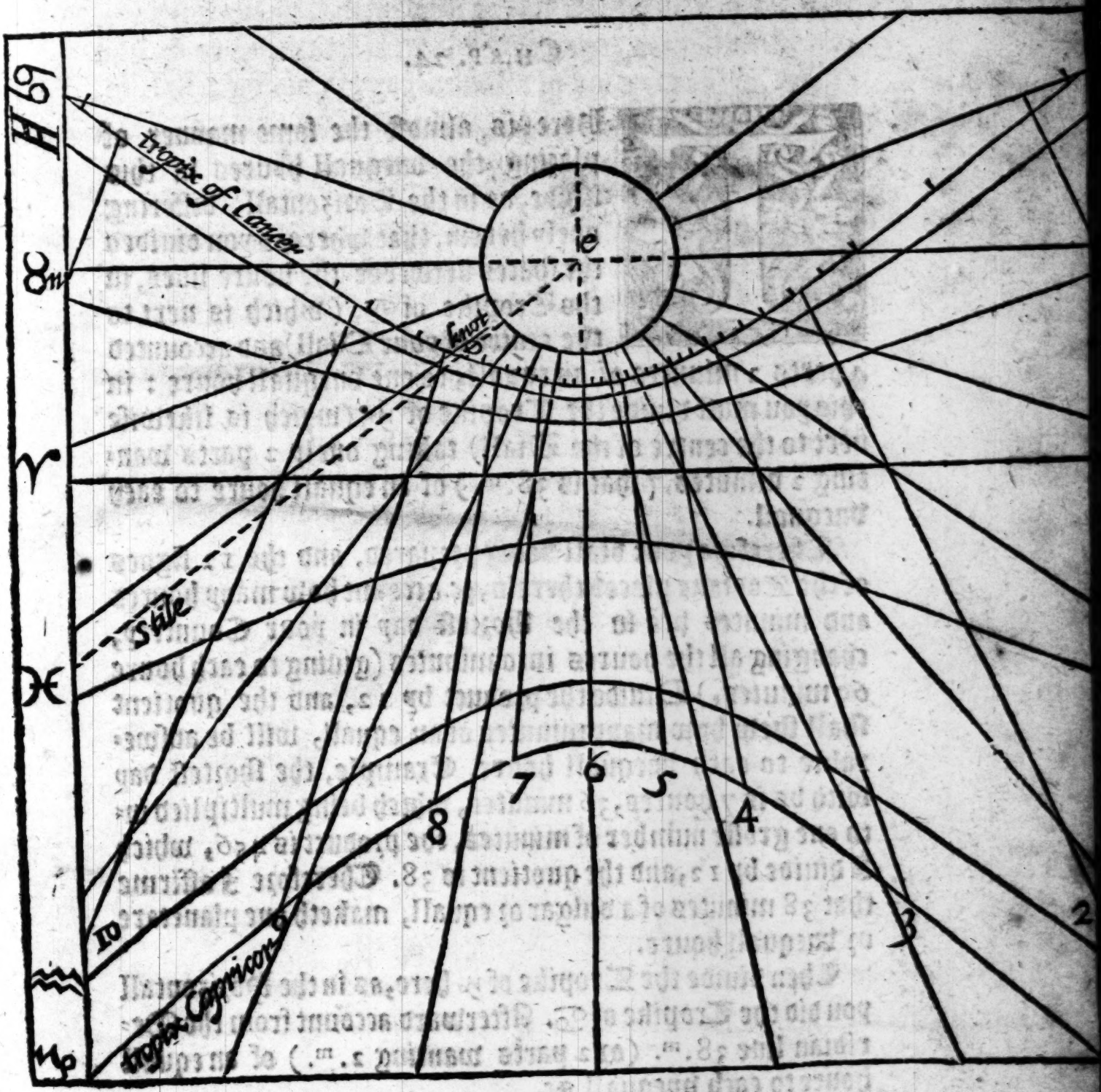
You may place the figures for the vnequall or planetrate houres, at the end of the lines vnder the Tropike of Capricorne, or aboue the line of Cancer as you will.

Note that the same part of the Stile which sheweth the 12 signes, shall likewise shew the vnequall houres. For better vnderstanding hereof:

Behold the Figure following.

A Hori-

An Horizontall Diall.



How

How to place the houres vnequall in a South erect & direct Diall.

Chap. 24.

THere is almost the same manner of placing the vnequall houres in this kinde, as in the Horizontall, differing onely herein, that whereas you diuided the spaces betweene the houre lines, in the Tropike of ♋, (which is next to the centre of your Diall) and accounted 4 parts 2 minutes of an equall, to one vnequall houre: in this you must diuide the Tropike of ♑, (which is likewise next to the centre of the Diall) taking onely 2 parts wanting 2 minutes, (that is 38.m.) of an equall houre to each vnequall.

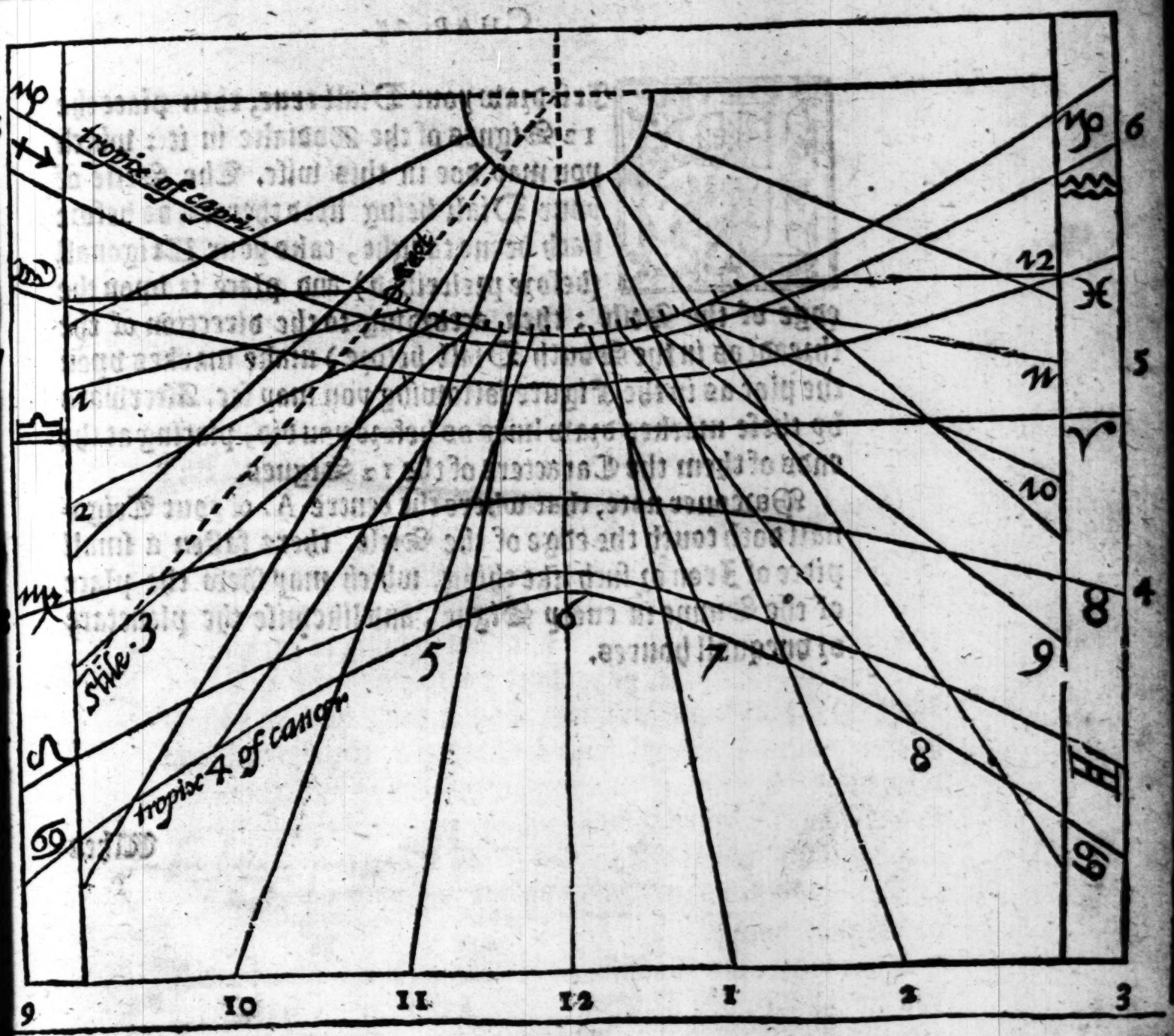
Therefore your diall being prepared, and the 12 signes of the Zodiake placed therein, &c. account how many houres and minutes bee in the shortest day in your Countrey, changing all the houres into minutes (giuing to each houre 60 minutes.) Diuide the product by 12, and the quotient shall shew how many minutes of an equall, will be answerable to each vnequall houre. Example, the shortest day with vs is 7 houres, 36 minutes, which being multiplied into one grosse number of minutes, the product is 456, which I diuide by 12, and the quotient is 38. Therefore I affirme that 38 minutes of a vulgar or equall, maketh one planetare or vnequall houre.

Then diuide the Tropike of ♑ here, as in the Horizontall you did the Tropike of ♋. Afterward account from the Meridian line 38.m. (or 2 parts wanting 2.m.) of an equall houre to each vnequall, &c.

Finish all things else in this Meridionall erect direct, as you were taught in the Horizontal. The figure ensueth.

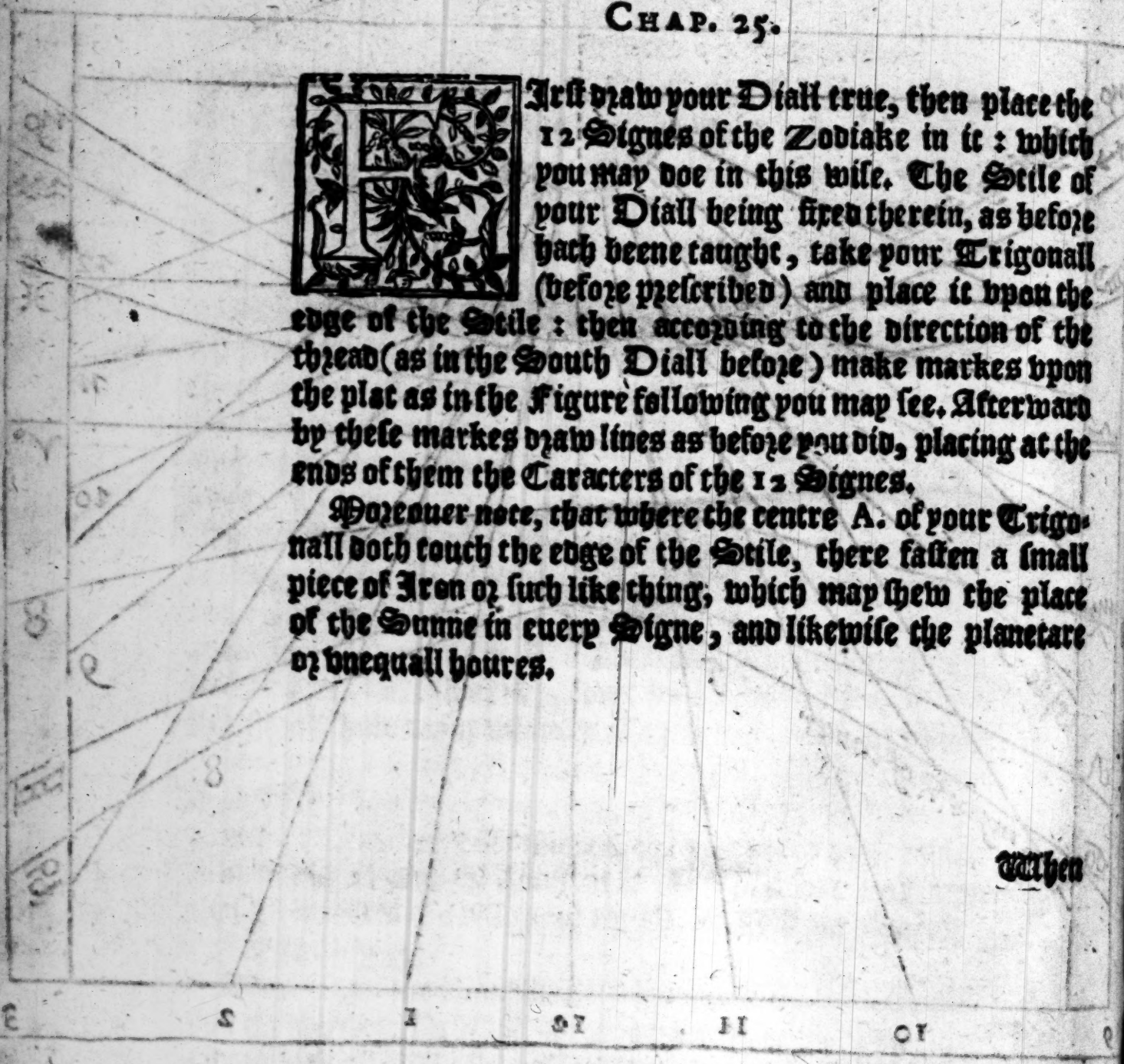
A South

A South Diall.



The placing of the houres vnequall in East and West Dials.

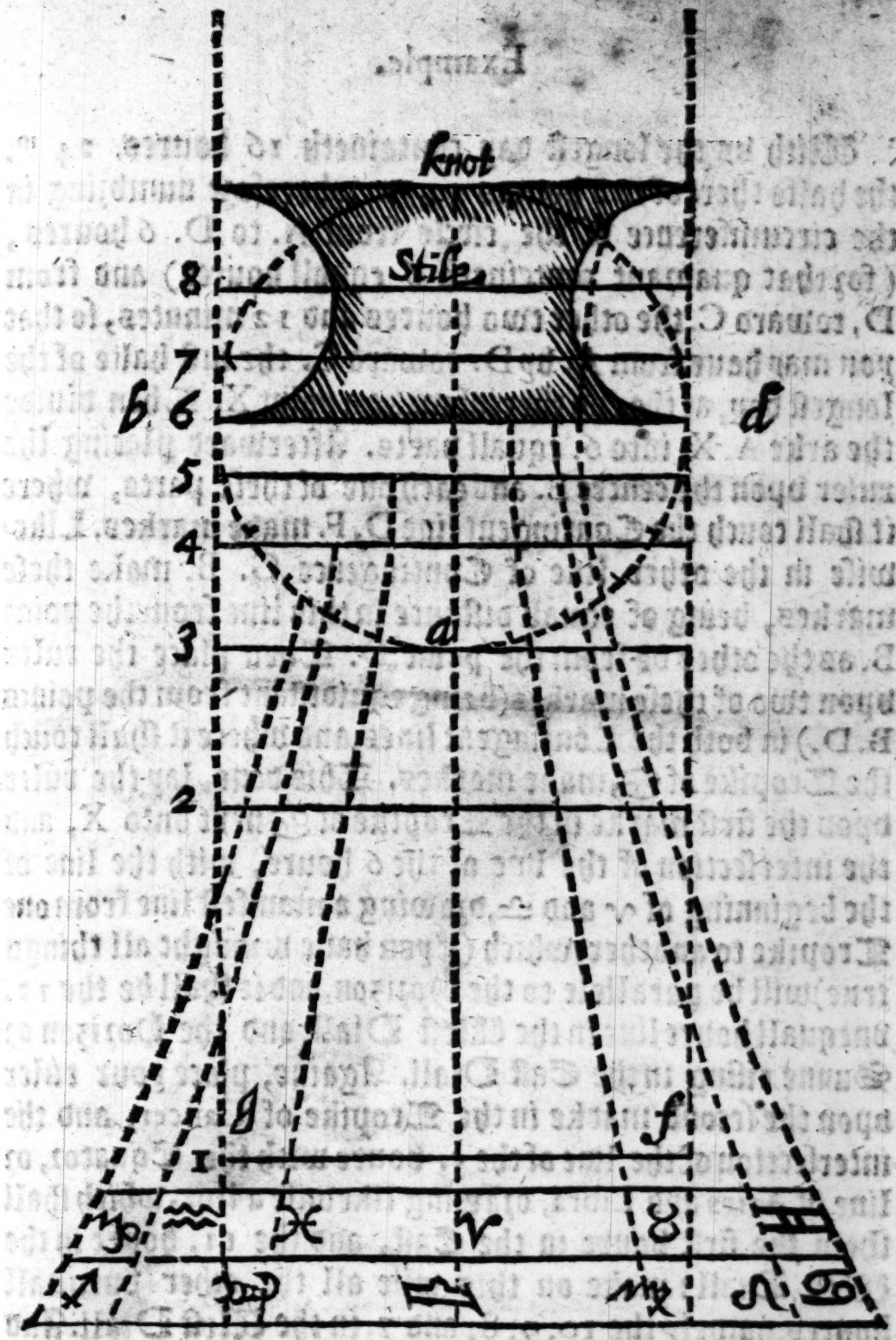
Chap. 25.



First draw your Diall true, then place the 12 Signes of the Zodiake in it: which you may doe in this wise. The Stile of your Diall being fixed therein, as before hath beene taught, take your Trigonall (before prescribed) and place it vpon the edge of the Stile: then according to the direction of the thread (as in the South Diall before) make markes vpon the plat as in the Figure following you may see. Afterward by these markes draw lines as before you did, placing at the ends of them the Caracters of the 12 Signes.

Moreouer note, that where the centre A. of your Trigonall doth touch the edge of the Stile, there fasten a small piece of Iron or such like thing, which may shew the place of the Sunne in euery Signe, and likewise the planetare or vnequall houres.

When



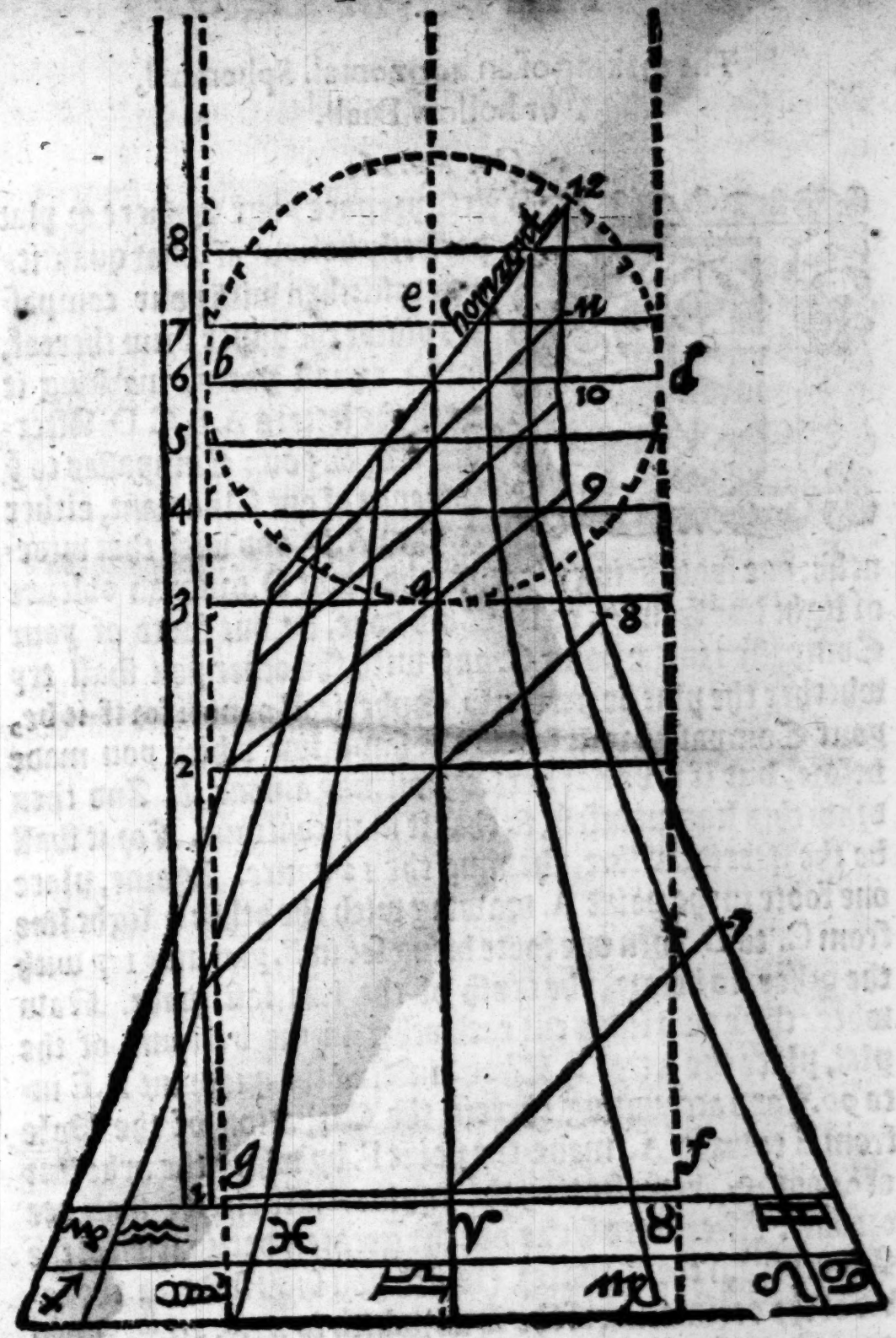
When as therefore you would place the houres vnequall in thole kinds of Dials, account the number of houres and minutes, which the halfe of the longeſt day in your Country doth conteine.

Example

Example.

With vs the longest day containeth 16 houres, 24.m. the halfe thereof is 8 houres 12.m. wherefore numbring in the circumference of the circle from A. to D. 6 houres, (for that quadrant conteineth 6 equall houres) and from D. toward C. the other two houres and 12 minutes, so that you may haue from A. by D. toward C. the iust halfe of the longest day, at the end thereof make a point X. Then diuide the arke A. X. into 6. equall parts. Afterward placing the ruler vpon the centre E. and each one of these parts, where it shall touch the Contingent line D. F. make markes. Likewise in the other line of Contingence G. B. make these markes, being of equall distance in this line from the point B. as the other be from the point D. Then place the ruler vpon two of these markes (being equidistant from the points B. D.) in both the Contingent lines, and where it shall touch the Tropike of ♋, make markes. This done, lay the ruler vpon the first marke in the Tropike of ♋ next vnto X, and the intersection of the line of the 6 houre, with the line of the beginning of ♈ and ♎, drawing a manifest line from one Tropike to another, which (if you haue wrought all things true) will be parallele to the Horizon, and it shall be the 12. vnequall houre line in the West Diall, and the Horizon or Sunne rising in the East Diall. Againe, place your ruler vpon the second marke in the Tropike of Cancer, and the intersection of the line of the 5. houre with the Equator, or line of Aries and Libra, drawing likewise a line, which shall shew the first houre in the East, and the 11. houre in the West Diall: make on this wise all the other vnequall houres, namely the 10, 9, 8, and 7, in the West Diall. And the 2, 3, 4. 5, in the East Diall.

The


12
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horizont
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b
d
10
5
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8
2
g
f

The making of an horizontall Sphericall, or hollow Diall.

Chap. 26.

First, prepare your Sphere or plat perfectly hollow, of what quantity you will: then with your compasses diuide the vpper brim thereof, into 4 equall parts, marking it with the letters A.B.C.D. Afterward vpon your Compasses to ye widenes of one Quadrant, either A.C. or A.D. and with that wideneſſe, one foote being placed in the point D. draw an obſcure or light line from A. to B. This done, ſet one foote of your Compaſſes in the point C. and with the other you ſhall try whether the plat be perfectly Sphericall or not: for if it be, your Compaſſes will fall in the ſame line which you made before, but if it be not perfect, you may amend it. And then draw this line manifeſt, ſo that it may continue. For it ſhall be the Meridian line, ſhewing the 12 houre. Againe, place one foote in the point A. drawing with the other a light line from C. to D. then one foote being ſet in B. you may try with the other, as before, the truth of the line laſt made. Now where theſe two lines cut each other in the bottome of the plat, place the letter E. Then diuiding the quadrant A.E. into 90.d. and accounting therein the Elevation of the Pole from E. toward A. make the point F. by which the arke line of ♈ and ♎, repreſenting the equinoctiall circle, ſhall bee drawne. Afterward ſeeke out the greateſt declination of the Sunne from the Equator, (which you ſhall finde in the table of the declination of the Sun) which is 23.d. 30.m. Then account 23.d. 30.m. from F. toward E. making there a marke for the arke of Cancer. Likewiſe from F. toward A. number the ſame diſtance, for the arke line of Capricorn. This done, account from F. toward E. 20.d. 12.m. make there alſo a mark

for

for the line of ♊ & ♌. And the like space from F. towards A. for the arke of ♐ & ♎. To conclude, number from F. towards E. 11.d. 30.m. making there also a marke for the line of ♉ and ♍: and so much from F. toward A. for ♓ and ♏.

When you haue thus made marks for all the arkes of the 12. Signes, open your compasses to the Quadrant of the Sphere, that is, from A. to C. which wideness of the compasses remaining, place one foote in the point F. in the arke of ♈ and ♎ in the Meridian: and where the other foot shall touch the same Meridian towards B. make the point G. which shall represent the Pole antartike, by which, as it were from a centre, draw a line from the point D. by F. to C. which shall be the line of Aries & Libra. Then one foote of your compasses remaining in the point G. with the other draw lines from one side of the plat to the other, by euery marke before made for the 12. Signes of the Zodiake.

The 12. Signes being thus finished, proceede to the diuision of the equall houres on this manner. Diuide the arke of the Equator into 12. equall parts, beginning at D. by F. ending in C. Then open your Compasses to the quadrant of the plat, and the same wideneſſe of them remaining, place one foote on the first point of the diuision next C. in the Equator, and if you haue diuided the Equator equally, the other foote will touch the first part beyond F. towards D. by which from the centre G. to the edge of the plat, draw a line, which shall shew the first houre afternoone. This done, remoue your compasses (that wideneſſe remaining) placing one foote in the second part from C. towards F. and the other foote touching the second part from F. towards D. make a line as before, from the centre G. to the brimme of the plat, to shew the 2. houre afternoone. In like manner, finish all the other houre lines, namely, the 3, 4, 5, 6, 7, 8, for the afternoone. Then doe likewise on the other side for the houres in the forenoone, namely, the 11, 10, 9, 8, 7, 6, 5, and 4, drawing lines from the centre G. by euery diuision, to the brimme of the plat, &c.

The placing of the vnequall houres in this Diall.

When you will place the houres vnequall in this Spherical Diall, diuide the Tropick of Cancer and Capricorne each of them into 12. equall parts, as before you did the Equator for the equall houres. Then with the compasses ioyne each three points of these three arkes, answerable into one line or arke, vntill you haue made 12. lines to shewe the 12. vnequall houres, as in the figure following you may see. Whereof the Meridian, or 12. vnequall houre shall alwaies be the 6. vnequall houre.

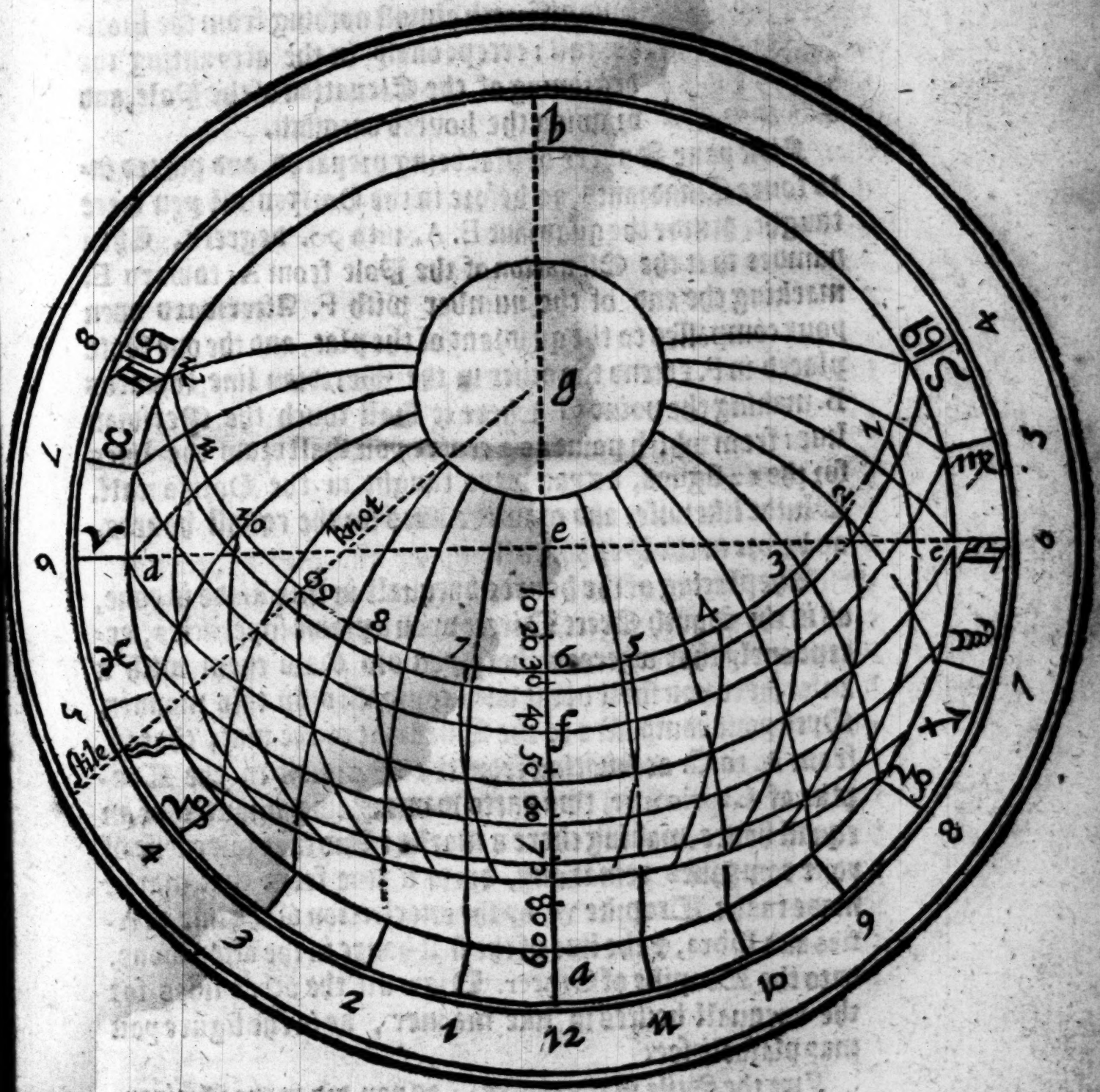
In placing the figures to the equall and vnequall houres, and the Caracters to the 12. Signes of the Zodiake, the figure may sufficiently shew, notwithstanding you may place them where you will, giuing to each signe his proper Caracter, and euery houre equall and vnequall their proper figures or names.

Fixe the Stile in the centre G. standing vp so high as the hymme of the plat, so that the vpper end may appeare as the centre of the circumference, which you may try, by placing a ruler vpon the points A. B. And againe vpon C. D. In like manner you may examine it with your Compasses, but the former, as practice will teach you, is the more conuenient way.

You may, if you will, haue the Stile stand aboue the plat, so that it may shew the equall houres aboue the edge of the Sphere, and then fasten a knot of equall height with the plat, which shall shew the motion of the Sunne in the 12. Signes and the vnequall houres, which otherwise the end of the Stile should doe: as in the figure following you may perceiue.

The

The Figure of an hollow Horizontall Diall.



The making of a South Spherical erect direct Diall.

Chap. 27.

YOu shall vnderstand, that the making of this kind differeth almost nothing from the Horizontall: except onely in the accounting the beginning of the Elevation of the Pole, and drawing the houres vnequall.

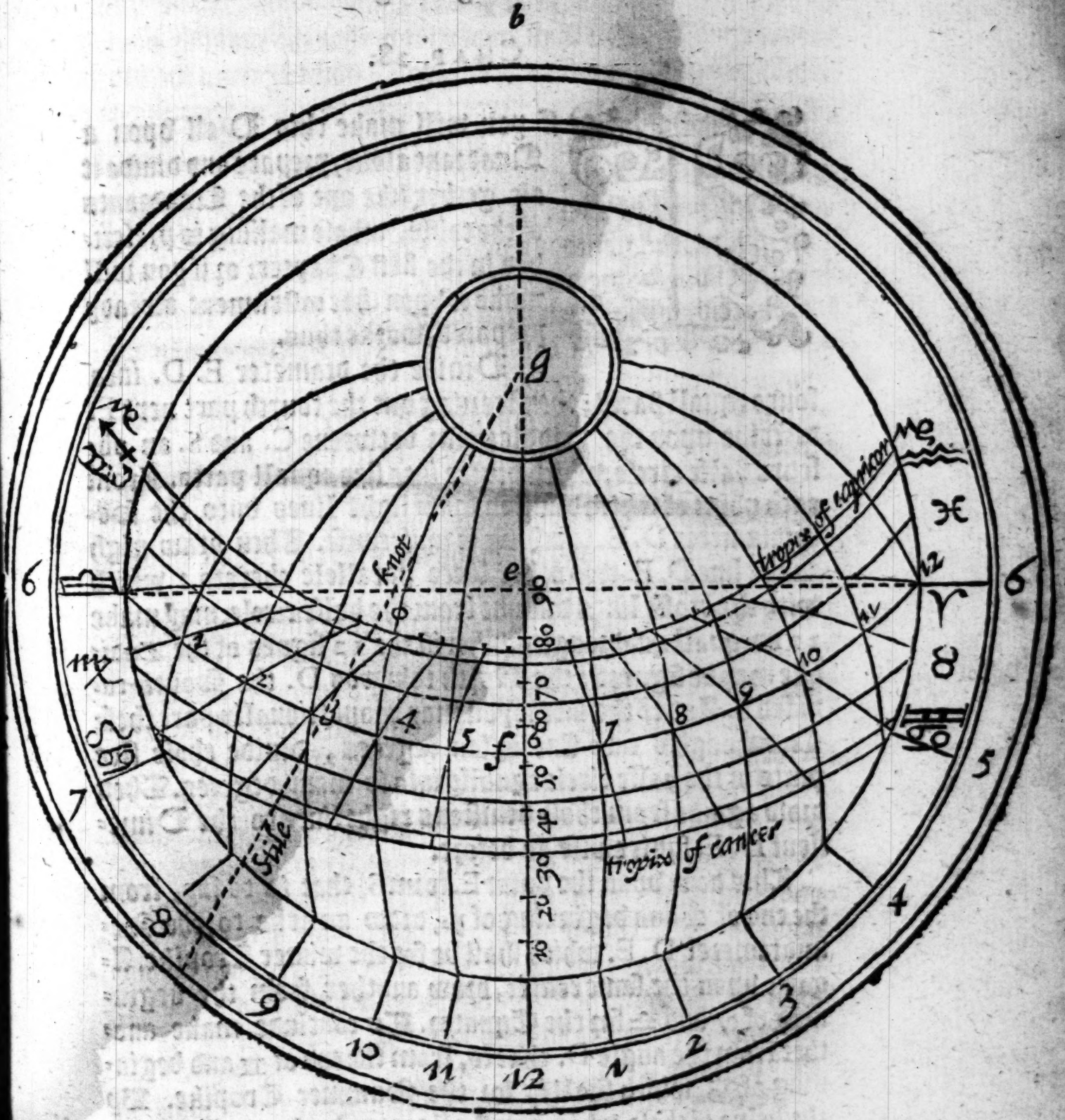
First your Sphere or plat being prepared, and parted into foure Quadrants, as before in the Horizontall you were taught, diuide the quadrant E. A. into 90. degrees. Then number in it the Elevation of the Pole from A. toward E. marking the end of the number with F. Afterward open your compasses to the quadrant of the plat, and the one foote placed in F. extend the other in the Meridian line towards B. making the point G. where it shall touch the Meridian line: from which point as a centre you shall draw the lines for the 12 signes, as you were taught in the Horizontall. Diuide likewise, and draw the lines for the equall houres, as before in the Horizontall.

The placing of the houres vnequall in this kinde is done, as in the South Erect Direct vpon a plaine superficies, except onely that whereas there you did draw them with a ruler, here you shall doe it with compasses on this manner. Open your compasses to the Quadrant of the plat, that is, from A. to C. accounting from the Meridian in the Tropike of Capricorne, two parts wanting two minutes of an equall houre, making there a marke: And that wideneſſe of your compasses remaining, draw a line from that marke made in the Tropike ♑, by the intersection of the line of Aries and Libra, & the line of the first houre in the afternoone, vnto the Tropike of Cancer. Draw all the other lines for the vnequall houres in like manner, as in the figure you may plainely see.

Fixe the Stile in the centre G. as you did in the Horizontall, placing the figures for the equall and vnequall houres,

and

and the caracters to the 12 signes, as in the example following, or otherwise as you will.



The

The making of a Diall vpon a Quadrant, or the Table described in the beginning of the Booke.

Chap. 28.

IF you will make this Diall vpon a Quadrant alone, prepare and diuide it altogether like one of the Quadrants of the table, whose making is prescribed in the first Chapter: or if you will make it vpon that instrument already prepared, worke thus.

Diuide the diameter E. D. into foure equall parts; then leauing out the fourth part next E. describe vpon the middle point betweene C. and S. an obscure halfe circle: which diuide into sixe equall parts. From each point of which diuision draw right lines vnto the Semidiameter D. E. touching it squirewise. Then draw nigh to the line D. E. two other lines parallele thereto: which with the crosse lines drawne from the halfe circle, may make 12 vnequall quadrangles, wherin the 12 signes of the Zodiake may be figured: the North towards D. the South toward S. And to the intent you may proportionally part these Quadrangles into fiue or ten degrees, diuide those sixe parts of the halfe circle equally into so many degrees. Then draw againe from those diuisions right lines to the Dimetient D. E. squirewise, as before.

This done vpon the point E. from S. that is to say, from the end of ♐ and beginning of ♑, draw an arke to the Semidiameter D. E. which shall be for the winter Tropike. Againe vpon the same centre, draw another from the beginning of ♈ and ♎ for the Equator. To conclude, make another from the angle D. that is, from the end of ♊ and beginning of ♋, which shall be for the Summer Tropike. By the helpe of these arkes, you shall draw the houre lines, so

that

that you first know the height of the Sunne aboue the Horizon, at euery houre, when it occupieth the beginning of ♈, ♉. and ♋. Whose altitude is thus found out.

Take the Eleuation of the Pole, and the Complement thereof: also the declination of the Sunne from the Equinoctiall, and the distance of the Sunne from the Meridian, accounting 15 degrees for euery houre, with the Complement of this distance. Then if you desire to know the altitude of the Sunne at sixe of the clocke either in the morning or at euening (at which houre onely in Summer it is aboue the Horizon) multiply the Sine of the Eleuation of the Pole, by the Sine of the declination of the Sunne, diuiding the product by the whole Sine, and you shall haue your desire.

But if the Sunne shall bee distant from the Meridian fewer houres then sixe, multiply the Sine of this distance (giuing to euery houre 15 degrees) by the Sine of the complement of the altitude of the Pole, and the product hereof diuide by the whole Sine. Then take the arke of the quotient from 90 degrees, and the first number found out shall remaine, which must bee kept. Then compare the Sine of this number found out, with the Sine of the Eleuation of the Pole, augment the lesser by the whole Sine, diuiding the product by the greater: Whereof shall come a quotient Sine, to the complement of whole arke adde the declination of the Sunne, if it shall be in the North signes, or subtract it from that, if it occupieth the South signes. And if the number which commeth hereof shall bee greater then 90, take it from 180, and you shall haue the second number found out. The Sine of this number found out being multiplied, by the Sine of the first number found out, shall yeeld a product, which part by the whole Sine, and the arke of the quotient Sine, shall shew the desired altitude of the Sunne for the houre propounded.

But if the distance of the Sunne from the Meridian shall exceede sixe houres (that is 90 degrees) take the de-

grees of that distance from 180, multiplying the Sine of the remainder by the Sine of the Complement of the altitude of the Pole, diuiding the product by the whole Sine, and subtract the arke of the quotient from 90, the remainder shall bee called, the First number found out. The Sine of which number found out, compared with the Sine of the Eleuation of the Pole, increase the lesser by the whole Sine, and distribute the product by the greater. Then take the Complement of the Declination of the Sun, from the arke of the quotient, and you shall haue the second number found out.

Finally, the Sine of the first number found out, and the Sine of the second being multiplied by themselues, and the product parted by the whole Sine; the quotient Sine shall yeeld an arke, which shall be the altitude of the Sunne.

But when the Sunne occupieth the beginning of ♈ or ♎ you shall finde the altitude thereof euery houre, onely by multiplying the Sine of the Complement of the distance of the Sunne from the Meridian, by the Sine of the Complement of the Eleuation of the Pole, diuiding the product by the whole Sine, the quotient which commeth hereof shall yeeld the arke of your desire. At both the fixe houres, because the one fixe is the rising, and the other the setting, there is then no altitude of the Sunne aboue the Horizon.

Moreouer, to know how much the Meridian altitude is, of the Sunne entring into ♋, adde the greatest Declination thereof, to the Complement of the Eleuation of the Pole: and by subtracting the greatest Declination of the Sunne, from the complement of the Eleuation of the Pole, you shall likewise haue the Meridian altitude of the Sunne entring into ♑.

You shall likewise seeke the height of the Sunne, being in the 10. degree of ♉ aboue the horizon, at 8 of the clock before noone, and at 4 after noone: at 7 in the morning, and 5

in the euening: at both 6. and the 5 houre in the morning. and 7. at night. Also at 5. in the morning and 7. in the euening, the Sunne being in the beginning of ♊.

But because the working of this, to finde out these altitudes, requireth much time and labour, wee will set downe these distances ready found out, calculated for the Eleuation of the Pole 50.d. and 52.d. which you may likewise vse without any notable difference, where the pole is Eleuated 49.d. 51.d. and 53.d.

The first table calculated for 50. *degrees.*

Hour.	Hour	♋		♈ ♎		♑		10 deg. ♉.		10 deg. ♊	
		D.	M	D.	M.	D.	M.	D.	M.	D.	M.
	12	63	30	40	0	16	30				
11	1	61	2	38	23	15	19				
10	2	54	42	33	50	11	51				
9	3	46	15	27	2	6	24				
8	4	36	53	18	45			30	23		
7	5	27	15	9	35			20	55		
6	6	17	47	0	0			11	19		
5	7	8	48					2	3	7	14
4	8	0	36							0	0

The second table calculated for 50. *degrees of latitude.*

Hour.	Hour	♋		♈ ♎		♑		10 deg. ♉.		10 deg. ♊	
		D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
	12	61	30	38	0	14	30				
11	1	59	13	36	28	13	21				
10	2	53	15	32	7	10	0				
9	3	45	12	25	33	4	45				
8	4	36	12	17	32			29	36		
7	5	25	53	8	46			19	22		
6	6	17	42	0	0			11	4		
5	7	8	58					2	4	7	46
4	8	F	F							0	0

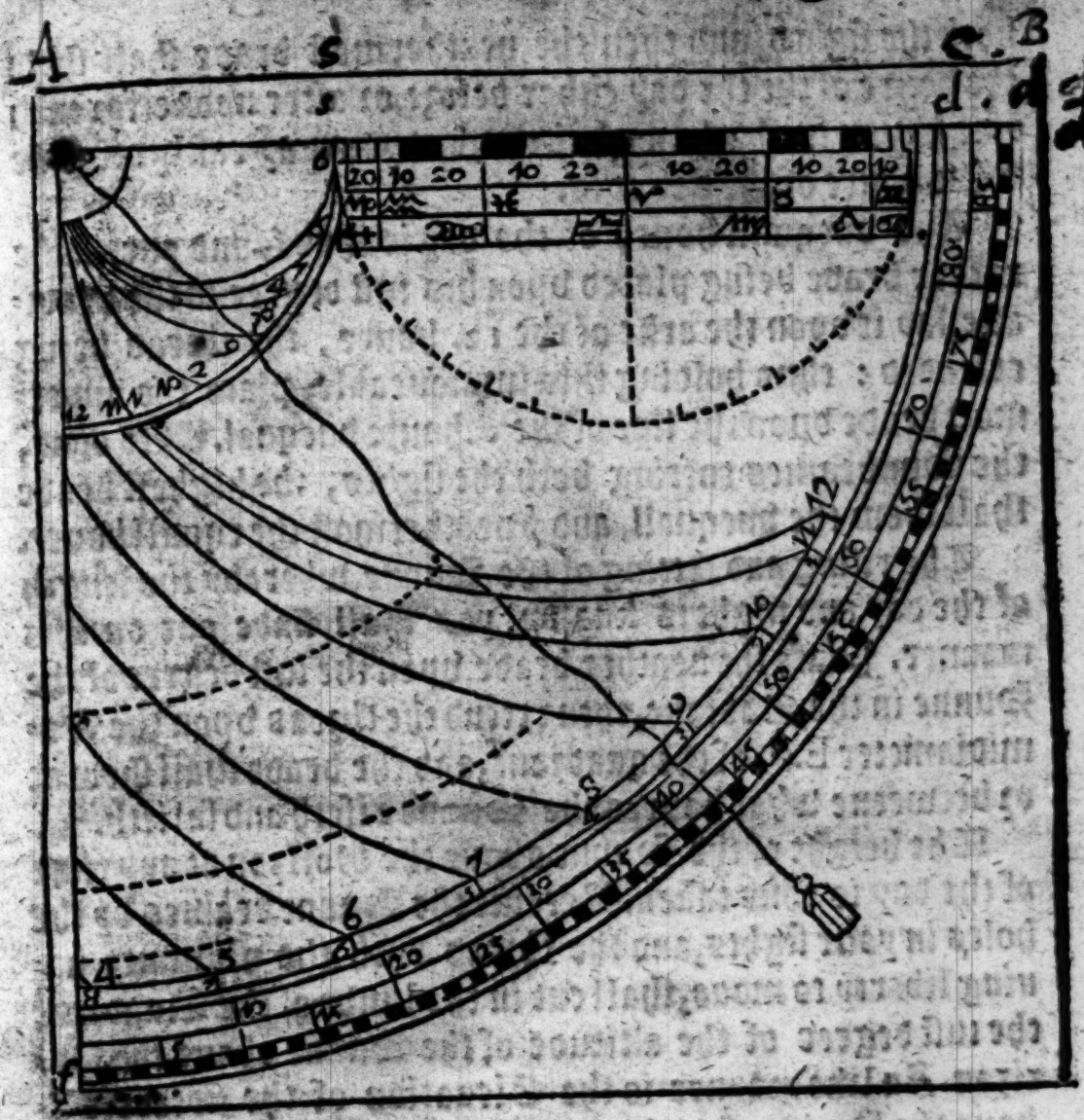
If therefore you will make your Quadrant Horologicall for the Elevation of the Pole 50.d extend a thread, or lay a Ruler, from the centre E. by the 63.d. 30.m. of the limbe of the quadrant, beginning at F. and where the thread so placed shall touch the Tropike of ♋, there make a point or marke. Againe, let the thread be placed vpon the 40.d. of the limbe, and where it shall touch the Equator, there also make a marke. Thirdly, let the thread be drawne by the 16.d. 30.m. of the quadrant: and where it shall touch the Tropike of ♑, there make likewise a marke. This done, search out the centre (by the 5. Proposition 4. Euclid) and ioyne these three markes into one arke, which shall bee the line for the 12. houre. Afterward place the thread vpon the 61.d.2.m. of the limbe, and where it shall cut the Tropike of ♋, note it. Draw likewise the thread vpon the 38.d. 23.m. of the limbe,

limbe, marke where it cutteth the Equator. Then by the 15.d. 19.m. of the limbe extend the thread, making a marke in the section thereof and the Tropike of ♑. Draw into one Arke these three markes (as you did before) finding out the common centre: so shall you haue the line of the 11. houre before noone, and 1. afternoone. In like manner are the rest of the houre lines drawne by three points, accounted and found out by the altitude of the sunne. But because before 9. and after three, in this Elevation of the Pole, it wil not serue for this delineation, there must another bee made by the table of the 12. Signes or Quadrangles. Therefore draw that from the 10.d. of ♉, so shall you haue a line or place wherein the third points may be marked. Then to prepare the points of the Arke for the houres of 8 and 4. of 7. and 5. and both the 6. besides the two markes made in the Tropike of ♋ and the Equator, let the third be noted in the arke drawne from the 10. degree of ♉. To draw the the line of the 5. & 7. houres, vse besides the Tropike of Cancer, and this drawne from the 10. degree of ♉, the third which shall come from the beginning of ♊. The line of 4. in the morning, and 8. in the euening is very short, included in the angle next vnto I. Thus you haue finished 9. arkes or lines for the houres, of which each one of them doth shew 2. houres: except one which is onely for the 12 houre.

And to the intent that there should be no space left voyd and vnprofitable betweene the Tropike of ♑ and the centre E. you may draw in that place the vnequall houres, which you shall very easily doe on this manner. Describe vpon the centre E. an arke very little distant from the Tropike of ♑, to bee diuided into 6. equall parts, and take the middle point betweene the beginning of that arke at S. and betweene E. Then vpon this point, as it were a centre, make a halfe circle from S. to E. which shall bee the line of the 6. vnequall houre, that is of midday. Afterward one foote of the compasses being placed in the same Semidiameter E. D. and remoued each way as occasion shall require:

and the other extended in the meane time so far, that it may touch the second point of the arke divided into 6. parts, and the centre E. draw an Arke or line from the centre to that point, which shall shew the 5. and 7. houres. In like maner are the other 4. drawne, one foote of the compasses being remoued, as necessity shall require, in the Semidiameter E.D. (which may be prolonged if it shalbe too short) and the compasses so opened, that the other foote may touch the point of the diuided Arke and the centre E. and ioyne them all into one Arke line: then fixe a thread in the center F. well waxed, hauing two small beades vpon it to moue with a plummet of iron or lead. Last of all prepare two sights of brasse or other metall with ioynts, which you must place in one right line vpon the side or edge A. B. so that you may direct them, and againe turne them downe vpon that side A. B. at your pleasure: that (if you make this Dial vpon the Table or instrument prescribed in the beginning of this booke) they be no hindrance to you in trying or examining of your plats. Thus is your diall prepared: but for further instruction beholde the Figure.

The



The vse of this Diall or quadrant Horologicall.

TO know the houre of the day when the Sunne shineth, worke thus. First, seeke out in some Calender in what signe and degree the Sun is at that day: then extend the thread with the beades vpon the Semidiameter E. D. and place the neathermost beade vpon that degree, in the Table of the 12. Signes, which the Sunne then occupieth. Afterward lifting vp your quadrant, the thread with the plummet hanging at libertie, let the Sun beames passe thorow both

both the sights, and then the neathermost beade shall shew the houre of the the day either before, or after noone: for each line as you see, hath two houres, but you may easily discerne what houre of the day it is.

The vnequall houre of the day is thus found out. The nether beade being placed vpon his iust degree in the Zodiake, lay it vpon the arke of the 12. houre, the thread being extended: thus holding this immoueable, place the vppermost beade vpon the line of the 6. houre vnequal. This done, the Sunbeames entring both the sights, the highest beade shall shew the vnequall, and ỹ neathermost the equall houre.

The rising and setting of the Sunne, whereby the length of the day and night is known, you shall finde out on this manner. Place the neather beade vpon the iust degree of the Sunne in the Zodiake, then extend the thread vpon the Semidiameter E.F. of the quadrant, and the beade shall shew at or betweene what houres the Sunne riseth and falleth.

The height of the Sunne aboue the Horizon at any time of the day is thus taken. Receiue the Sunne beames by the holes in your sights, and the thread with the plummet hauing liberty to moue, shall cut in the limbe of the Quadrant the iust degree of the altitude of the Sunne aboue the Horizon. In like manner is the Eleuation of the Starres aboue the Horizon searched out.

You shall find out the Eleuation of the Pole by the helpe of your Quadrant, thus. Take the height of the Sunne at 12. of the clocke, when the dayes and nights be of equall length, which being subtracted from 90.d. the Eleuation remaineth. But if you assay that vpon any other day then the Equinoctiall, you must consider whether the Sunne occupieth the North, or the South signes, and then vse the table of the Declination of the Sunne on this wise. When the Sunne is in the North signes, subtract his declination from the Meridian height thereof. But if it be in the South signes, adde the declination to his Meridian altitude. The remainder or totall summe being taken from 90.d. the Eleuation of the Pole shall remaine.

How

How to make an instrument, whereby you may know the iust houre of the night by the Starres.

Chap. 27.

FIrst prepare a plat or Table of brasse or firme and solid wood, which will not change or bend, somewhat thinne, let the forme of it be round, three inches broad, or more or lesse as you will. Draw a circle nigh vnto the edge, and diuide it into 12. equall parts: wherein shall be placed the 12. Signes of the Zodiake, then diuide each of these parts into 30. equall parts, which shall shew the number of the daies that the Sunne moueth in euery Signe. Make a second circle, wherein you may number the daies, and a third circle, wherein write the Caracters of the 12. Signes, as you see in the figure following.

Degrees

Draw likewise another circle, wherein you may write the dayes of euery month in the yeere, which you may doe by any Calender, but for more easinesse behold the Table following, whereby you may likewise doe it.

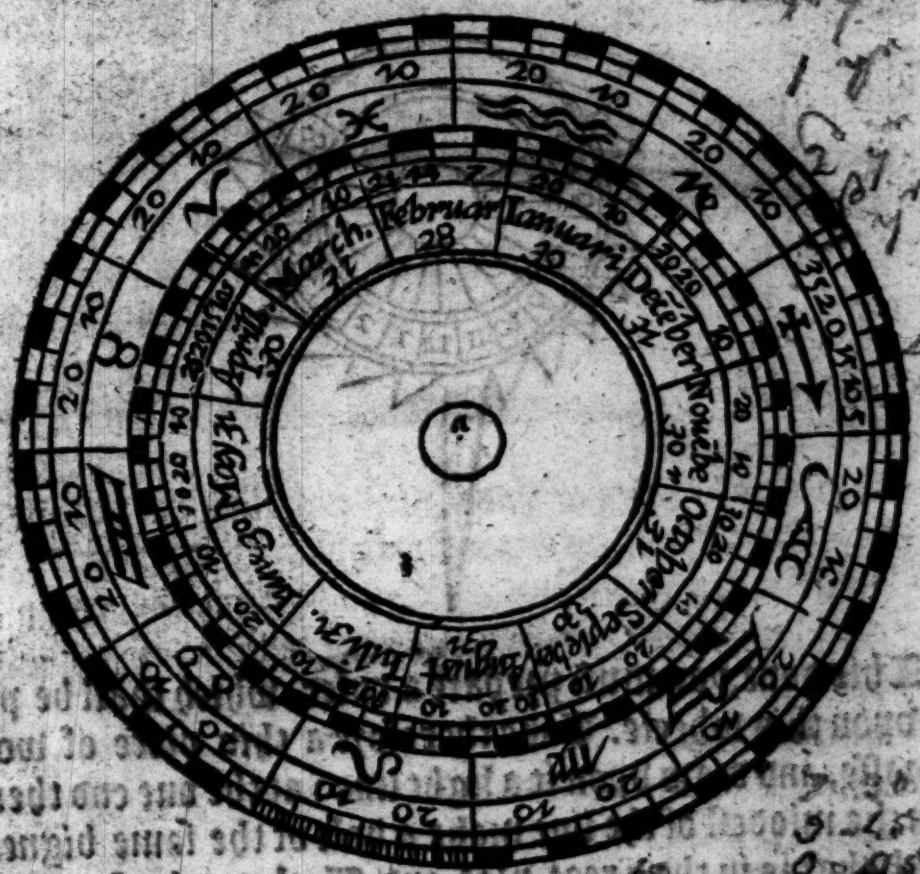
New Stile	Month.	Daies.	Deg. (New stile)		M.	Caracters of the 12 Signes.	Signes.
♑ 10.20	January	1	20	10.40	13	♑	Capricorne.
25.25		15	5	25.28	33	♒	Aquarius
♒ 10.30		31	21	11.43	44	♒	
25.57	February	14	5	25.53	52	♓	Pisces.
♓ 9.53		28	19	9.38	48	♓	
24.52	March	15	4	24.56	36	♈	Aries.
♈ 10.40		31	20	10.46	28	♈	
25.20	Aprill	15	40	25.29	51	♉	Taurus.
♉ 10. 2		30	19	10. 5	13	♉	
24.32	May	15	4	24.34	38	♊	Gemini.
♊ 8.57		30	18	8.57	50	♊	
24. 3	June	15	3	24.15	8	♋	Cancer.
♋ 8. 4		30	17	8.38	22	♋	
22.14	July	15	1	23.19	40	♌	Leo.
7.57		31	16	8.36	38	♌	
♌ 22.10	August	15	1	23. 0	24	♍	Virgo.
♍ 7.50		31	16	8.27	58	♍	
♎ 22.15	Septem.	15	1	22.35	40	♎	Libra.
♎ 7.10		30	16	7.18	30	♎	
21.48	October	15	1	22.8	30	♏	Scorpius.
♏ 8. 7		31	17	8.6	43	♐	
23.	November	15	2	23.11	30	♐	Sagittarius.
♐ 8.22		30	18	8.22	13	♑	
24.	December	15	3	23.38	38	♑	Capricorne.

Enter this Table, and you shall finde that the first day of January must be placed against ♑ 20.d.13.m. of Capricorne, and the 15. day against the 5.d.33.m. of Aquarius, &c.

Therefore lay your ruler vpon the centre A. of your plat, and vpon the 20.d.13. of ♑, and where it shall touch the circle which you made for the daies of euery moneth, there make a marke which shall shew the first day of January. Then lay it vpon the 5.d.33.m. of ♒ and the centre A. and where it shall touch the circle, make a marke for the 15. day of January. Then lay your ruler vpon A. and the 21.d. 44.m. of ♒, and make likewise a marke for the 31. day of January. Againe place the ruler vpon the centre A. and the

5.d.

5.d.52.m. of ♓, for the 14 day of February: worke thus with all the reſt, vntill you haue ſet downe the beginning and middeſt of euery month, as the Table doth direct you, then hauing found out the beginning & middeſt of euery month, you may at eaſe diuide euery ſpace into ſo many parts, as there be daies in the month, which it ſerueth for, according as you ſee in this figure following. It ſhall be alſo neceſſary to make one circle to write the number of the daies of the moneth, and another for the names of the months: you muſt make alſo a hole in the centre of this plat, of ſuch bigneſſe, as you may ſee a Starre thorow it: as in the figure you may perceiue.



Hauing prepared this plat with the circles vpon it, for the 12. Signes and months, you muſt prepare another wheele full of teeth, which you ſhall make on this manner.

Take a thinne Table or platte of the ſame matter your

other was, draw a circle vpon it so great as the inward circle of the first plat, and diuide it into 24. equall parts. Then draw lines from the centre to euery one of those parts, vntill you haue so many as there be houres in the longest night in your Countrey. Then cut teeth by these lines for the houres, and write the number of them vpon the teeth as you see in this figure. Let the tooth for the 12. houre be so long from the centre to the end, as is betweene the centre A. of the other plat, and the circle of the 12. Signes: you must likewise make a hole in the centre of this wheele, of the same bignesse of that in the other plat.

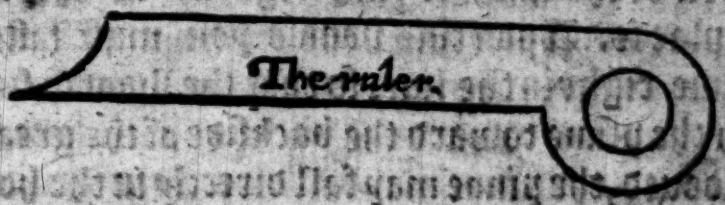
The Tothed wheele.



This done, you must prepare a ruler, which shall be placed vpon this wheele. Take therefore a thin piece of wood or brasse, and draw vpon it a light line: at the one end thereof in the middest of the line make a hole of the same bignesse which that is in the great plat and Tothed wheele. Then draw a circle halfe an inch wide or more if you will, afterward cut the ruler round at the end, cutting off likewise the one halfe of the breadth of the ruler by the line.

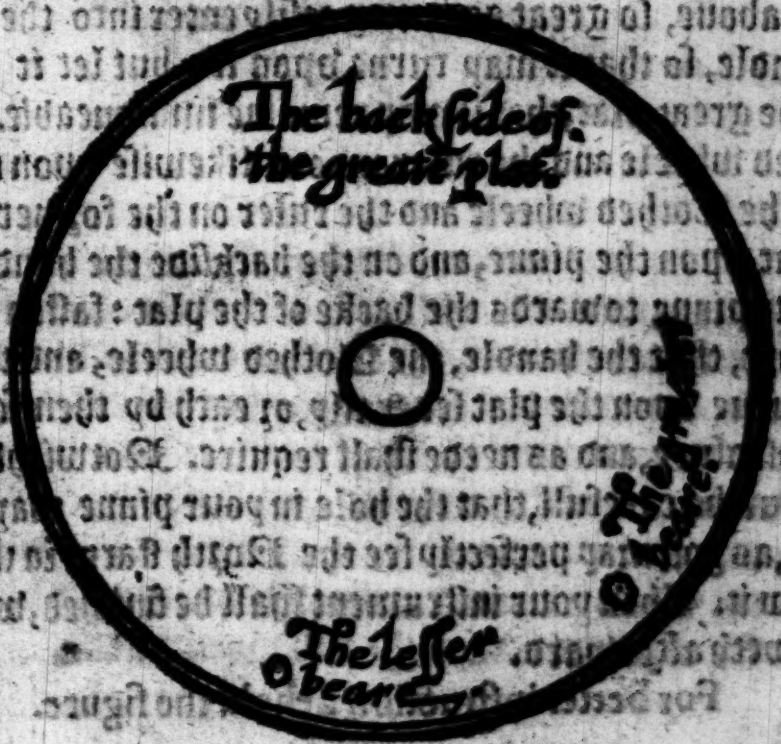
Let

Let the length of the ruler from the centre to the end bee of such quantity, as is from the centre of the great plat to the outward edge, and an inch or more if you will.



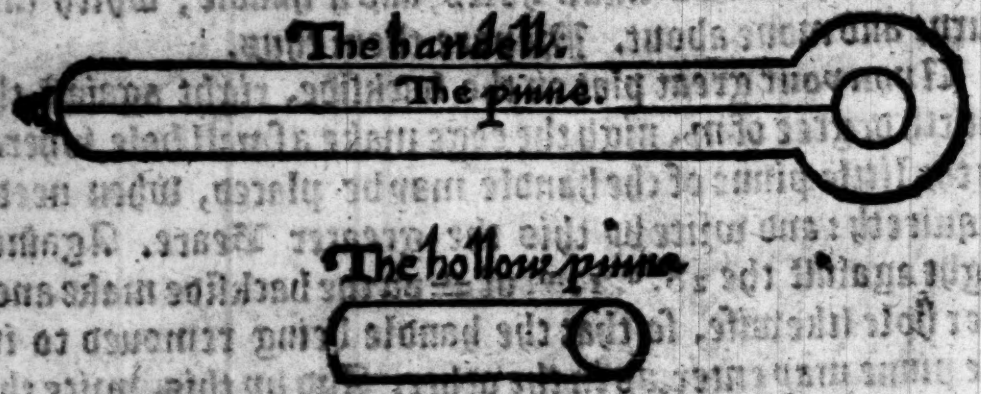
The foreside of your instrument being finished: the backside must haue two small holes, and a handle, which may turne and moue about. Prepare them thus.

Upon your great plat on the backside, right against the fourth degree of ♑, nigh the edge make a small hole, wherein the little pinne of the handle may be placed, when neede requireth: and write by this the greater Beare. Againe, right against the 28. ᵈ. 11ᵐ. of ♎ on the backside make another hole likewise, so that the handle being remoued to it, the pinne may enter, as in the other. And by this, write the lesser Beare, &c.



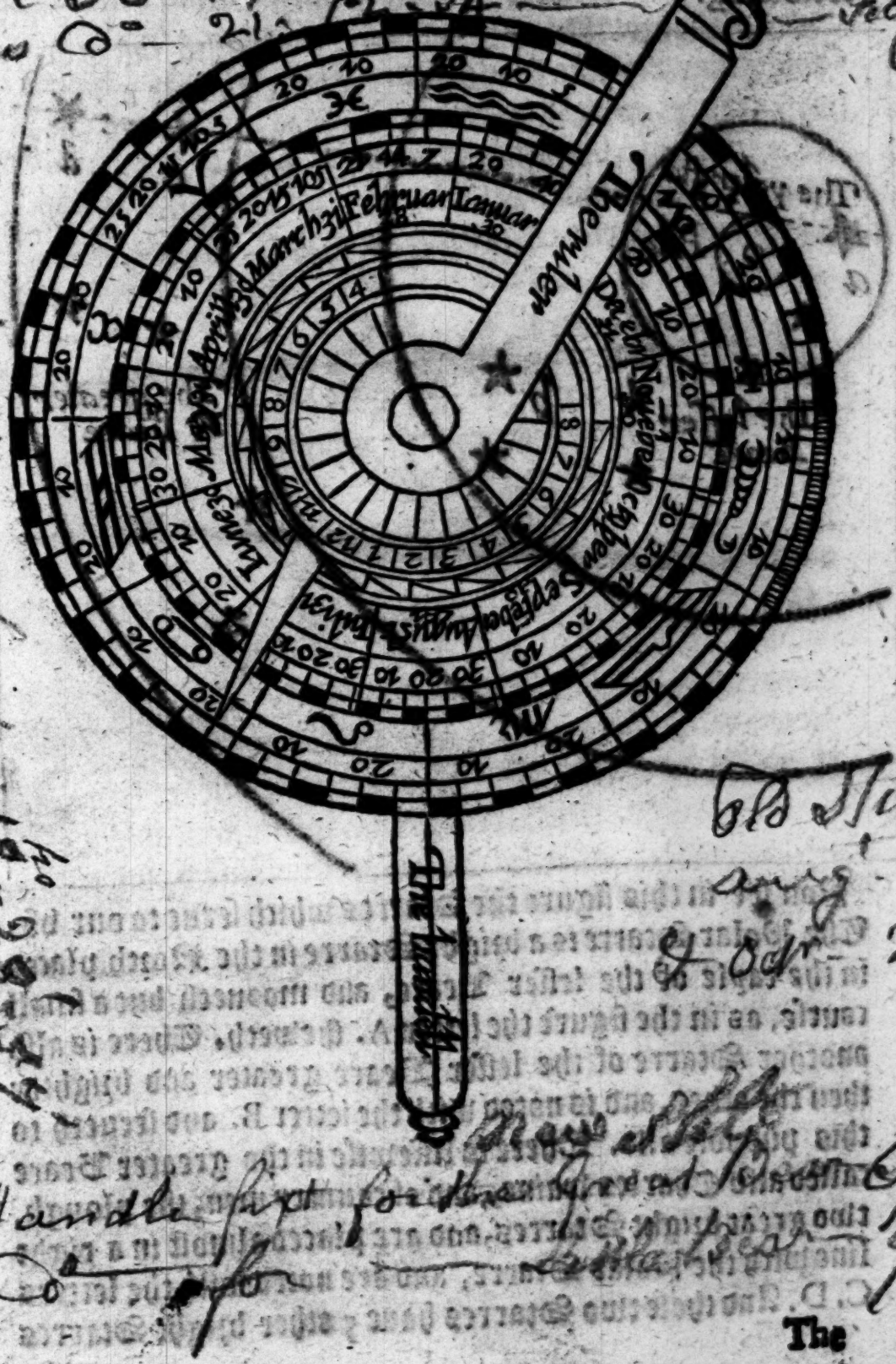
Prepare for your handle a thin plate of yron, braſſe, or wood, about 6 inches in length, or more if you will. Draw in the middeſt of it a line: at the one end thereof make a hole in the middeſt of the line, of ſuch bigneſſe as the hole in the greater plat is. Upon this handle you muſt faſten a little ſhort pinne right in the line, ſo that the handle being faſtened with the pinne toward the backſide of the great plat, and being mooued, the pinne may fall directly in the hole.

Behold the figure following.



Prepare a hollow pinne of yron or braſſe, according to this figure aboue, ſo great as it may eaſily enter into the hole of the handle, ſo that it may turne vpon it: but let it go cloſe into the great plat, that it may remaine immoueable. Let the Toothed wheele and the ruler mooue likewiſe vpon it. Then place the Toothed wheele and the ruler on the former ſide of the plat vpon the pinne, and on the backſide the handle with the litle pinne towards the backe of the plat: faſten them ſo together, that the handle, the Toothed wheele, and the ruler may turne vpon the plat ſeuerally, or each by themſelues at your pleaſure, and as neede ſhall require. Notwithſtanding you muſt be carefull, that the hole in your pinne may bee ſo great, as you may perfectly ſee the North ſtarre in the night thorow it. Then your inſtrument ſhall be finiſhed, whoſe vſe followeth afterward.

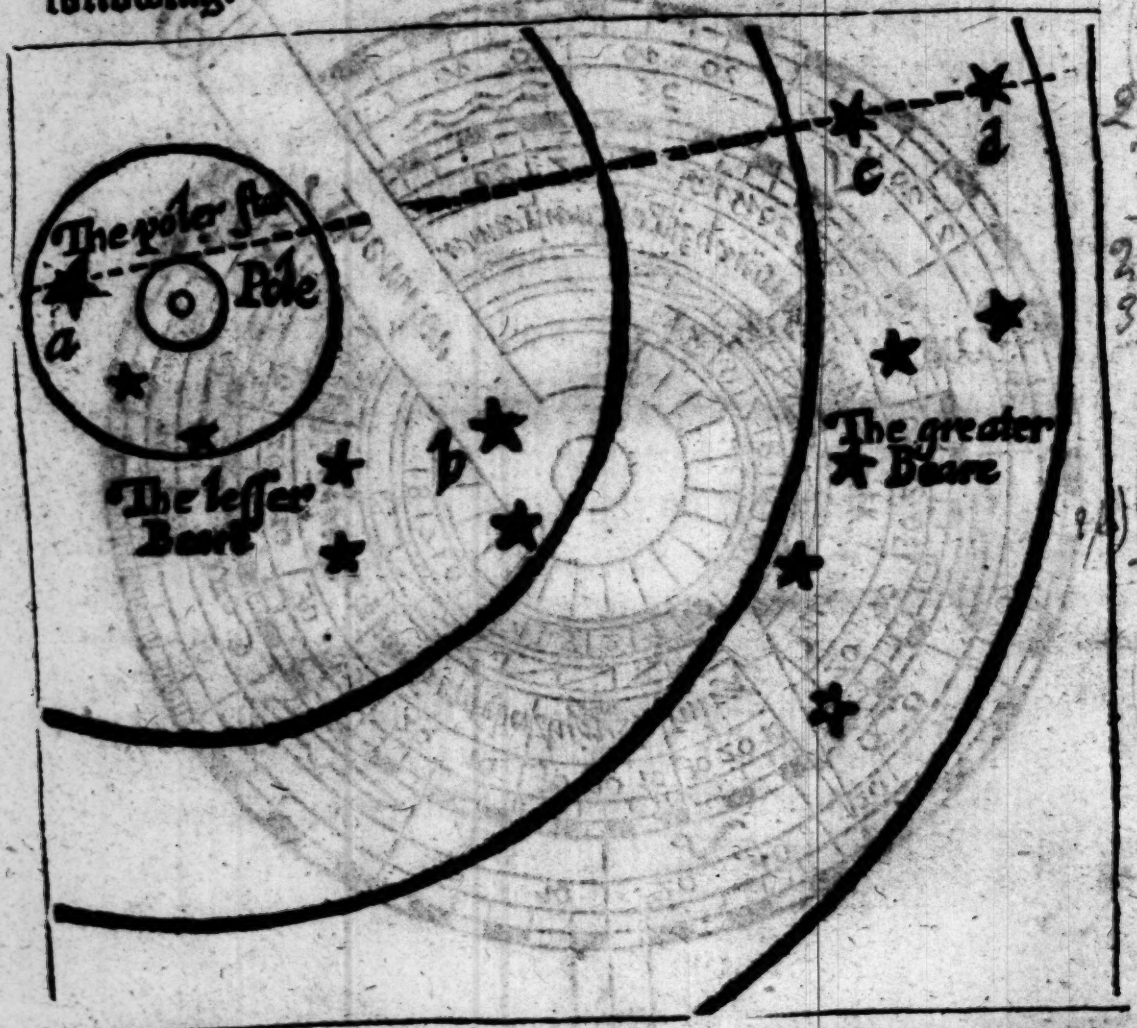
For better inſtruction behold the figure.


November
December
January
February
March
April
May
June
July
August
September
October
The Gnomon

The

The vse of this instrument.

FIrst it shall be expedient to finde out the Starres seruing to this purpose, which you may doe by the figure following.



You see in this figure the Starres which serue to our vse. The Polar Starre is a bright Starre in the North, placed in the tayle of the lesser Beare, and mooueth but a small course, as in the figure the letter A. sheweth. There is also another Starre of the lesser Beare greater and brighter then the other, and is noted with the letter B. and serueth to this purpose also. There is likewise in the greater Beare called also Charles waine, and of country men, the plough, two great bright Starres, and are placed almost in a right line with the Polar Starre, and are noted with the letters C. D. And these two Starres haue 5 other bright Starres by

by them, but not so great as the other be. These Starres which you see in ỹ figure, as all other, moue equally aboute the Pole, and finish their course in 24 houres.

Therefore when you would know the houre of the night by this instrument, doe thus: Place the right line of the long tooth of the 12 houre directly ouer the day of the moneth, and turne the handle on the backside to the hole of the greater beare, and your instrument shall be prepared.

Then lift vp your instrument by the handle perpendicularly, so that it declineth on neither sides: and beholding the Polare Starre thorow the hole in the centre, moue the ruler aboue, vntill the right line thereof be directly against, or seemeth to touch the two Starres of the greater beare, and vnder the line you shall haue the iust houre of the night: which you may finde out by the number of the teeth with your figure in the night. But if you cannot see the two Starres of the greater beare, because of clouds: and yet you may see the Polare Starre, and the Starre of the lesser beare, noted with the letter B. remoue ỹ handle on the backside to the hole of the lesser beare. Then lift vp your instrument as before, and behold the Polare Starre at the hole, and turne the ruler to the foresaid Starre of the lesser beare, and you shall finde the true houre of the night, as before is taught.

The making of a Diall, to knowe the houre by the Moone.

Chap. 30.



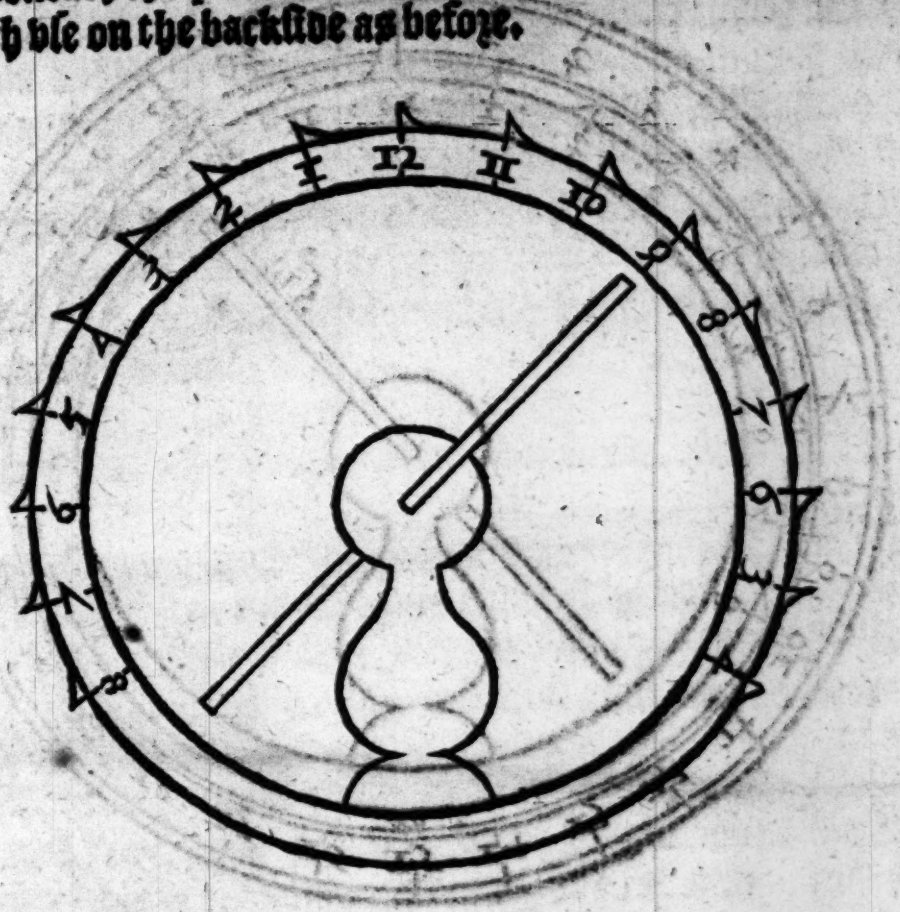
Prepare a square piece of wood or metal 3. or 4. inches ouer, draw thereon a circle so great as you can, draw also another within that. Now because the Moone finisheth her course in 29 dayes, 12 houres, and 44 minutes, part the inward into 30 parts in this maner; let 29 be equally diuided, and the 30 which is the last must not be so great by a third part: wherefore diuide one of these 29

equall parts into three parts, and take two of them for the 30. and last part.

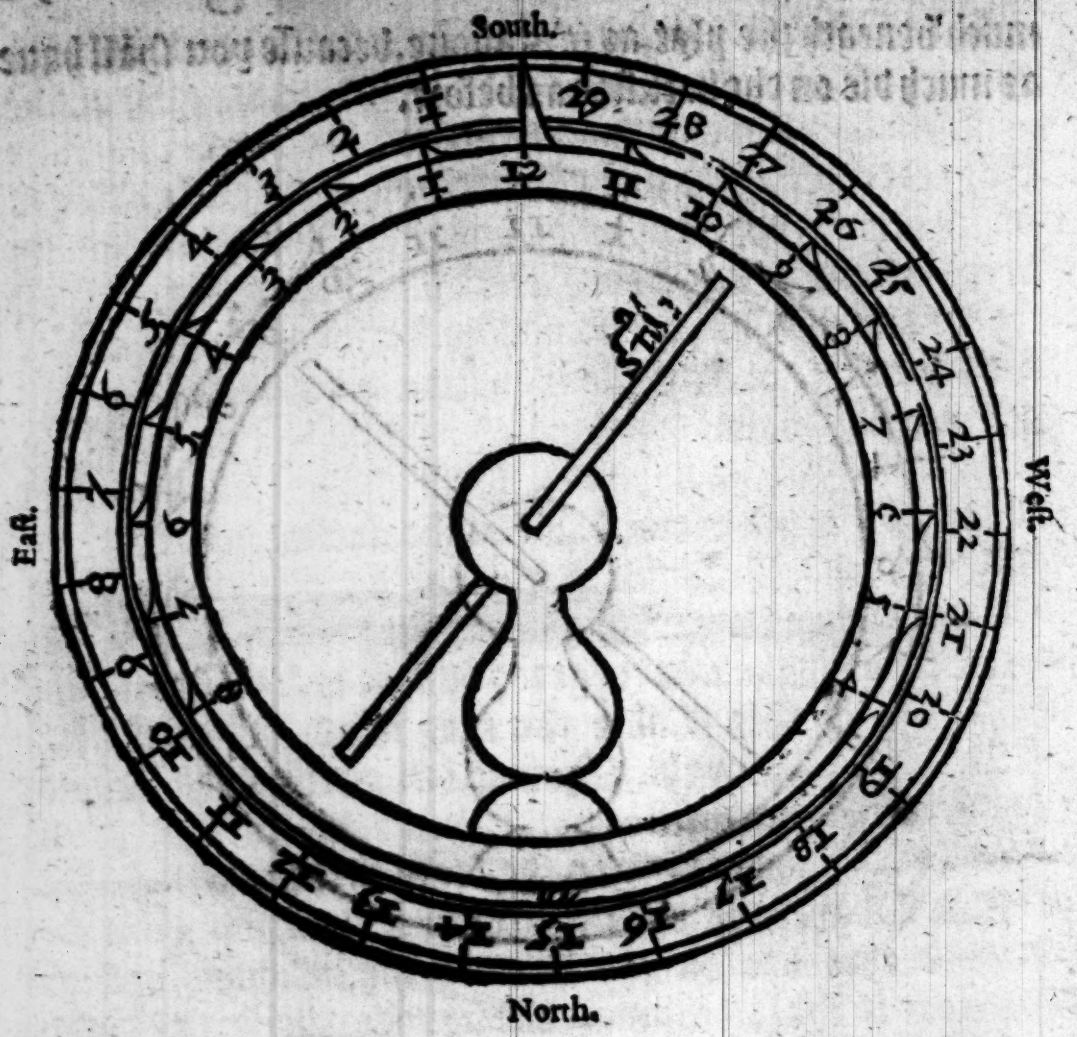


Cut out that which is within the inward limb, and prepare another of the same, or like wood or metall somewhat thicker, and worke it so that it may goe into the former, so much of the thicknes as it may be equall on the backside, and that which remaineth of the thicknesse, let it hang ouer the foreside of the first plate, to keepe it from falling downe: draw a circle vpon it, and diuide it into 24. equall parts: draw from these parts houre lines so many as shall suffice for the longest night: cut that which ouerhangeth with teeth at euery houre, but especially at the 12. houre make a long tooth, fixe a wyer in the centre for the Stile equally distant from the circle on each side. Let the Stile hang so much

much beneath the plat, as it is aboue, because you shall haue as much vse on the backside as before.



Cut out all that which is within the inward circle, except a little portion to support the Stile, so that this shall be but as a hoope. Draw the houre lines on the backside of this plat, as on the forepart, so that the one may be right against another: then draw lines on the inside, from euery one of these lines on the forepart, to the lines on the backside. This plat or wheele must be moueable, and turne within the former.



The vse of this Diall.

PLace this Dial that each side may behold one quarter of the world precisely: the South side the South, the North side the North, &c. Moreouer, it must recline according to the eleuation of the Equinoctiall, so that the Moone being in the Equinoctiall circle, shall giue light both aboue and beneath this Diall. You may place it perfectly with your Instrument.

Your Diall being thus placed, when you would know the houre of the night, first learne the age of the Moone by an almanack, and especially the houre of the change, then turne the great ouer-hanging tooth, to the day of the Moone on the first limb, and the houre of the change, accounting from 12. of the clocke.

The

The shadow of the Stile shall shew the houre of the nighe either beneath your Diall or else aboue.

This Diall will serue also for the Sunne, if you turne the great tooth of the moueable wheele to the little strick A. which is right opposite to the beginning of the first, and end of the last day of the Moone, neere ♑ 15. day, and then it is fit for the Sunne. For it differeth nothing from the North reclining direct, where the Reclination is equall to the Eleuation of the Pole.

The vse of the Table of the declination of the Sunne.

TAke what degree you will of any signe, and by this Table you may know his declination from the Equinoctiall circle. The Signes are written partly on the head of the Table, and partly on the foote of the same.

The Degrees in the first columne doe serue for the Signes that bee on the head of the Table, and the Degrees in the last columne doe serue for the Signes in the foote of the Table. And the common Area or angle against the Signe and the degree which you seeke for, doth containe the Degrees and Minutes of the Declination due to the same.

Example.

I would know how much the tenth degree of Leo doth decline from the Equinoctial: I must looke in the columne ouer Leo, right against the number of 10. in the last column, where I finde 17.d.46.m. the declination thereof, &c.

The Table of the declination of the Sunne, from the Equinoctiall circle.

	Aries. Libra.		Taurus. Scorpius.		Gemini. Sagittarius.	
Deg.	Deg.	M.	Deg.	M.	Deg.	M.	Deg.
1	0	24	11	30	20	12	29
2	0	48	12	11	20	35	28
3	1	12	12	31	20	47	27
4	1	36	12	52	20	58	26
5	1	59	13	12	21	9	25
6	2	23	13	32	21	20	24
7	2	47	13	52	21	30	23
8	3	11	14	12	21	40	22
9	3	34	14	31	21	49	21
10	3	58	14	50	21	58	20
11	4	21	15	9	22	7	19
12	4	45	15	27	22	15	18
13	5	8	15	55	22	23	17
14	5	32	16	3	22	30	16
15	5	55	16	21	22	37	15
16	6	18	16	39	22	44	14
17	6	41	16	56	22	50	13
18	7	4	17	13	22	55	12
19	7	27	17	29	23	1	11
20	7	50	17	46	23	5	10
21	8	12	18	2	23	10	9
22	8	35	18	17	23	13	8
23	8	57	18	33	23	17	7
24	9	19	18	48	23	20	6
25	9	41	19	2	23	22	5
26	10	3	19	17	23	24	4
27	10	25	19	31	23	26	3
28	10	47	19	44	23	28	2
29	11	8	19	58	23	29	1
30	11	29	20	12	23	30	0
Deg.	Deg.	M.	Deg.	M.	Deg.	M.	Deg.
	Virgo. Pisces.		Leo. Aquarius.		Cancer. Capricorne.	

The Table of Sines.

The whole Sine conteineth 100000. parts.

The vse of the Table of Sines.

Whereas the making of some Dials, and this Table of Sines may seeme obscure and hard to them who are not acquainted with Sinicall computation, it shall be expedient to declare the vse hereof, so much as perteineth to the vnderstanding of this booke, omitting all other vses as impertinent to our present purpose. Wherefore know that the Graues or Degrees are found in the vpper head of this Table, and the Minutes pertaining to the Degrees on the left side, & in the Area or common meeting of them both, a number which is called the Sine, answerable to each Degree and Minute, offereth it selfe. Againe, the Sine being found out, you may easily know the arke, that is, the Degree and Minutes thereof, these being on the left hand, the other on the head or vpper part. Vnderstand by the Complement that which remaineth of any number being taken or substracted from 90. Degrees. If at any time you enter the Table with iust Degrees without any Minutes, resolue one Degree into 60. Minutes, and then seeke out his Sine. And whereas you shall finde some numbers imperfect, you must remember to supply their want with those which be perfect immediatly going before.

what is ment by ye Sine?

Arke how Known?

Example.

The Eleuation of the Pole at Cambr. is 52. Degrees, whose Sine I desire to know, therefore resoluing one of the Degrees into Minutes, I enter the Table with 51. degrees,

grees, 60. Minutes, and the common Area I finde the Sine to be 78801. If then you desire to know the complement of this Elevation, subtract 52. out of 90. and the remainder shall be 38. the complement thereof, and entring the Table with 37.d. 60.m. you shall finde in the Area 66. which number because it is imperfect, you must supply the want thereof by adding the 3. former figures in that which is next before perfect, to wit, 615. and then the whole number shall be 61566. the Sine of 38.d. Which is the Complement of 52.d. the Elevation of the Pole.

These things well considered, there is nothing in the booke so obscure, but it shall seeme plaine and easie.

FINIS.

BRITISH
15 AP 1908
MUSEUM

D	0	1	2	3	4	5
M	Parts	Parts	Parts	Parts	Parts	Parts
1	29	1774	3519	5262	7004	8744
2	58	1803	48	91	33	73
3	87	32	77	5320	62	8803
4	116	61	3606	49	91	31
5	45	90	35	78	7120	60
6	74	1919	64	5407	49	89
7	203	48	93	36	78	8918
8	32	77	3722	65	7207	47
9	61	2007	51	95	36	76
10	90	36	80	5524	65	9005
11	319	65	3809	53	94	34
12	49	94	38	82	7323	63
13	78	2123	67	5611	52	92
14	407	52	96	40	81	9121
15	36	81	3925	69	7410	50
16	65	2210	55	98	39	79
17	94	39	84	5727	68	9208
18	523	68	4013	56	97	37
19	52	97	42	85	7526	66
20	81	2326	71	5814	55	94
21	610	55	4100	43	84	9323
22	39	85	29	72	7613	52
23	69	2414	58	5901	42	81
24	98	43	87	30	71	9410
25	727	72	4216	59	7700	39
26	56	2501	45	88	29	68
27	85	30	74	6017	58	97
28	814	59	4303	46	87	9526
29	43	88	32	75	7816	55
30	73	2617	61	6104	45	84

D	0	1	2	3	4	5
M	Parts	Parts	Parts	Parts	Parts	Parts
31	901	2646	4391	6133	7874	9613
32	30	75	4420	62	7903	42
33	59	2704	49	91	32	71
34	89	34	78	6220	61	9700
35	1018	63	4507	50	90	29
36	47	92	36	79	8019	58
37	76	2821	65	6308	48	87
38	1105	50	94	37	77	9816
39	34	79	4622	66	8106	45
40	63	2908	52	95	35	74
41	92	37	81	6424	64	9903
42	1221	66	4710	53	93	31
43	50	95	39	82	8222	60
44	79	3034	68	6511	51	89
45	1208	53	97	40	80	10018
46	38	82	4826	69	8309	47
47	67	3112	55	98	38	76
48	96	41	84	6627	67	10105
49	1425	70	4914	56	96	34
50	54	99	43	85	8425	65
51	83	3228	72	6714	54	92
52	1512	57	5001	43	83	10221
53	41	86	30	72	8512	50
54	70	3315	59	6801	31	79
55	99	44	88	30	70	10308
56	1628	73	5117	59	99	37
57	57	3402	46	88	8628	69
58	87	31	75	6917	57	94
59	1716	60	5204	46	86	10423
60	45	89	33	75	8715	52

D	6	7	8	9	10	11
M	Parts	Parts	Parts	Parts	Parts	Parts
1	10481	12215	13946	15672	17393	19109
2	10510	44	74	15700	17422	38
3	39	73	14003	29	50	66
4	68	12302	32	58	97	95
5	97	31	61	87	17508	19223
6	10626	60	90	15801	36	52
7	55	89	14118	44	65	80
8	84	12417	47	73	93	19309
9	10713	46	76	15901	17622	37
10	42	75	14205	30	51	66
11	71	12504	34	59	79	94
12	99	33	62	88	17708	19423
13	10828	62	91	16016	37	51
14	57	91	14320	45	65	80
15	86	12619	94	74	94	19500
16	10915	48	78	16102	17822	37
17	44	77	14406	31	51	66
18	73	12706	35	60	80	94
19	11002	35	64	89	17908	19623
20	31	64	93	16217	37	51
21	60	93	14521	46	66	80
22	89	12821	50	75	94	19708
23	11119	50	79	16303	18023	37
24	46	79	14608	32	51	65
25	75	12908	37	61	80	95
26	11204	37	65	89	18109	19822
27	33	66	94	16418	37	51
28	62	94	14723	47	66	79
29	91	13023	52	76	94	19908
30	11320	52	80	16504	18223	36

D	6	7	8	9	10	11
M	Parts	Parts	Parts	Parts	Parts	Parts
31	11349	13081	14809	16533	18252	19965
32	78	13110	38	62	80	93
33	11407	39	67	90	18309	20022
34	35	67	96	16619	37	50
35	64	95	14924	48	66	79
36	93	13225	53	76	95	20107
37	11522	54	82	16705	18423	36
38	51	83	15011	34	52	64
39	80	13312	39	62	80	93
40	11609	40	68	91	18509	20221
41	38	69	97	16820	38	50
42	67	98	15126	48	66	78
43	95	13427	54	77	95	20307
44	11724	56	83	16906	18623	35
45	53	85	15212	34	52	64
46	82	13513	41	63	80	92
47	11811	42	69	92	18709	20421
48	40	71	98	17020	38	49
49	69	13600	15327	49	66	78
50	98	29	56	78	95	20506
51	11927	58	84	17106	18823	35
52	55	86	15413	35	52	63
53	84	13715	42	64	80	93
54	12013	44	71	92	18909	20620
55	42	73	99	17221	38	48
56	71	13802	15528	50	66	77
57	12100	30	57	78	95	20705
58	29	59	85	17307	19013	34
59	58	88	15614	36	52	62
60	86	13917	43	64	80	91

D	12	13	14	15	16	17
M	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*
1	20819	22523	24220	25910	27591	29264
2	48	51	48	38	27619	92
3	76	80	76	66	47	29320
4	20904	22608	24305	94	75	48
5	33	36	33	26022	27703	76
6	61	65	61	50	31	29404
7	90	93	89	78	59	31
8	21018	22721	24417	26106	87	59
9	47	50	46	34	27815	87
10	75	78	74	62	43	29515
11	21104	22806	24502	90	71	43
12	32	35	30	26218	99	70
13	60	63	58	46	27927	98
14	89	91	87	75	54	29626
15	21217	22920	24615	26303	82	54
16	46	48	43	31	28010	81
17	74	76	71	59	38	29709
18	21303	23004	99	87	66	37
19	31	33	24728	26415	94	65
20	59	61	56	43	28122	93
21	88	89	84	71	50	29820
22	21416	23118	24812	99	78	48
23	45	46	40	26527	28206	76
24	73	74	69	55	34	29904
25	21501	23203	97	83	62	31
26	30	31	24925	26611	89	59
27	58	59	53	39	28317	87
28	87	87	81	67	47	30015
29	21615	23316	25009	95	73	42
30	43	44	38	26723	28401	70

D	12	13	14	15	16	17
M	Parts	Parts	Parts	Parts	Parts	Parts
31	21672	23372	25066	26751	28429	30098
32	21700	23401	94	79	57	30126
33	29	29	25122	26807	85	53
34	57	57	50	35	28513	81
35	85	85	78	63	40	30209
36	21814	23514	25206	91	68	36
37	42	42	35	26920	96	64
38	71	70	63	48	28624	92
39	99	99	94	76	52	30320
40	21927	23627	25319	27004	80	47
41	56	55	47	32	28708	75
42	84	83	75	60	36	30402
43	22013	23712	25403	88	63	31
44	41	40	32	27116	91	58
45	69	68	60	44	28819	86
46	98	95	88	72	47	30514
47	22126	23825	25516	27200	75	41
48	54	53	44	28	28903	69
49	83	81	72	56	31	97
50	22211	23909	25600	84	58	30624
51	39	38	28	27311	86	52
52	68	66	57	39	29014	80
53	96	94	85	67	42	30707
54	22325	24022	25713	95	70	35
55	53	51	41	27423	98	63
56	81	79	69	51	29125	91
57	22410	24107	97	79	53	30818
58	38	35	25825	27507	81	46
59	66	63	53	35	29209	74
60	95	92	81	63	37	30901

D	18	19	20	21	22	23
M	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*
1	30929	32584	34229	35863	37487	39909
2	57	32611	56	91	37514	39126
3	84	39	84	35918	41	53
4	31012	66	34311	45	68	80
5	39	94	38	72	95	39206
6	67	32721	65	99	37622	33
7	95	49	93	36029	49	60
8	31122	76	34420	53	76	87
9	50	32804	47	81	37703	39313
10	78	31	75	36108	30	40
11	31205	59	34502	35	57	67
12	33	86	29	62	84	94
13	61	32914	57	89	37811	39420
14	88	41	84	36216	37	47
15	31316	69	34611	43	64	74
16	44	96	39	70	91	39501
17	71	33023	66	98	37918	27
18	99	51	93	36325	45	54
19	31426	78	34720	52	72	81
20	54	33106	48	79	99	39607
21	82	33	75	36406	38026	34
22	31509	61	34802	33	53	61
23	37	88	29	60	80	88
24	64	33216	57	87	38107	39714
25	92	43	84	36514	33	41
26	31620	70	34911	41	60	68
27	47	98	38	68	87	94
28	75	33325	66	95	38214	39821
29	31702	53	93	36623	41	48
30	30	80	35020	50	68	74

D	18	19	20	21	22	23
M	Parts	Parts	Parts	Parts	Parts	Parts
31	31758	33408	35047	36677	38295	39901
32	85	35	75	36704	38322	28
33	31831	62	35102	31	48	54
34	40	90	29	58	75	81
35	68	33517	56	85	38401	40008
36	95	45	84	36812	29	34
37	31923	72	35211	39	56	61
38	51	99	38	66	83	88
39	78	33627	65	93	38510	40114
40	32006	54	93	36920	36	41
41	33	82	35320	47	63	68
42	61	33709	47	74	90	94
43	88	36	74	37001	38617	40221
44	32116	63	35401	28	44	48
45	43	91	29	55	71	74
46	71	33819	56	82	97	49301
47	99	46	83	37109	38724	27
48	32226	73	35510	36	51	54
49	54	33901	37	63	78	81
50	81	28	75	90	38805	40407
51	32309	55	92	37217	31	34
52	36	83	35619	44	58	60
53	64	34010	46	71	85	87
54	91	37	73	98	38912	40514
55	32419	65	35700	37325	49	40
56	46	92	28	46	65	67
57	74	34119	55	79	92	93
58	32501	47	82	37406	39019	40620
59	29	74	35809	33	46	47
60	56	34202	36	60	73	73

D	24	25	26	27	28	29
M	Parts	Parts	Parts	Parts	Parts	Parts
1	40700	42288	43863	45424	46972	48506
2	26	42314	89	50	98	31
3	53	40	43915	76	47024	57
4	79	67	41	45502	49	82
5	40806	93	67	28	75	48608
6	33	42419	93	54	47101	33
7	59	46	44020	80	26	58
8	86	72	46	45606	52	84
9	40912	98	72	32	78	48709
10	39	42525	98	58	47203	35
11	65	51	44124	83	29	60
12	92	77	50	45709	55	85
13	41018	42604	76	35	80	48811
14	45	30	44202	61	47306	36
15	71	56	28	87	31	62
16	98	83	54	45813	57	87
17	41124	42709	81	39	83	48912
18	51	35	44307	64	47408	38
19	77	62	33	90	34	63
20	41204	88	59	45916	60	88
21	30	42814	85	42	85	49014
22	57	40	44411	68	47511	39
23	83	67	37	94	36	65
24	41310	93	63	46019	62	90
25	36	42919	89	45	88	49115
26	63	46	44515	71	47613	41
27	89	72	41	97	39	66
28	41416	98	67	46123	64	91
29	42	43024	93	49	90	49217
30	69	51	44619	74	47715	42

D	24	25	26	27	28	29
M	Parts	Parts	Parts	Parts	Parts	Parts
31	41495	43077	44645	46200	47741	49267
32	41522	43103	71	26	67	92
33	48	29	97	52	92	49318
34	75	56	44723	78	47818	43
35	41601	82	49	46303	43	68
36	28	43208	75	29	69	94
37	54	34	44801	55	49	49419
38	80	61	27	81	47920	44
39	41707	87	53	46406	45	70
40	33	43313	79	32	71	95
41	60	39	44905	58	96	49520
42	86	65	31	84	48022	45
43	41813	92	57	46509	47	71
44	39	43418	83	35	73	96
45	65	44	45009	61	98	49621
46	92	70	35	87	48124	46
47	41918	96	61	46612	49	72
48	45	43523	87	38	75	97
49	71	49	45113	64	48200	49822
50	98	75	39	90	26	47
51	42024	43601	65	46715	51	73
52	50	27	91	41	77	98
53	77	54	45317	67	48302	49823
54	42103	80	43	92	28	48
55	29	43706	69	46818	53	73
56	56	32	95	44	79	99
57	82	58	45321	70	48404	49924
58	42209	84	47	95	30	49
59	35	43810	73	46921	55	74
60	61	37	99	47	80	50000

D	30	31	32	33	34	35
M	Parts	Parts	Parts	Parts	Parts	Parts
1	50025	51528	53016	54488	55943	57381
2	50	53	41	54512	66	57405
3	75	78	65	37	91	29
4	50100	51603	90	61	56015	52
5	25	28	53115	85	39	76
6	51	53	39	54610	63	57500
7	76	78	64	34	87	24
8	50201	51703	89	58	56112	48
9	26	28	53213	83	36	71
10	51	52	38	54707	60	95
11	76	77	63	31	84	57619
12	50302	51802	87	56	56208	43
13	27	27	53312	80	32	67
14	52	52	36	54804	56	98
15	77	77	61	29	80	57714
16	50402	51902	86	53	56304	38
17	27	27	53410	77	28	62
18	52	51	35	54902	52	85
19	77	76	59	26	76	57809
20	50502	52001	84	50	56400	33
21	28	26	53508	75	24	56
22	53	51	33	99	48	80
23	78	76	58	55023	72	57904
24	50603	52100	82	48	96	28
25	28	25	53607	72	56520	51
26	53	50	31	96	44	75
27	78	75	56	55120	68	99
28	50703	52200	80	45	92	58022
29	28	25	53705	69	56616	46
30	53	49	29	93	40	70

D	30	31	32	33	34	35
M	Parts	Parts	Parts	Parts	Parts	Parts
31	50778	52274	53754	55217	56664	58093
32	50803	99	79	45	88	58117
33	29	52324	53803	68	56712	41
34	54	49	28	90	36	64
35	79	73	52	55314	60	88
36	50904	98	77	39	84	58212
37	29	52423	53901	63	56808	35
38	54	46	26	87	32	59
39	79	72	50	55411	56	83
40	51004	97	75	36	80	58306
41	29	52522	99	60	56904	30
42	54	47	54024	84	27	54
43	79	71	48	55508	51	77
44	51104	96	72	32	75	58401
45	26	52621	97	57	99	24
46	54	46	54121	81	57023	48
47	79	70	46	55605	47	72
48	51204	95	70	29	71	95
49	29	52720	93	53	95	58519
50	54	45	54219	77	57119	42
51	79	69	44	55702	42	66
52	51304	94	68	26	60	90
53	29	52819	93	50	90	58613
54	54	43	54317	74	57214	37
55	79	68	41	98	38	60
56	51404	93	66	55822	62	84
57	28	52917	90	46	86	58707
58	53	42	54415	71	57309	31
59	68	77	39	95	33	54
60	51503	91	63	55919	57	78

D	36	37	38	39	40	41
M	Parts	Parts	Parts	Parts	Parts	Parts
1	58802	60204	61589	62954	64301	65627
2	25	27	61611	77	23	49
3	49	51	34	99	45	71
4	72	74	57	63022	67	93
5	96	97	80	45	90	65715
6	58919	60320	61703	67	64412	35
7	43	44	26	90	34	59
8	66	67	49	63112	56	81
9	90	90	72	35	79	65803
10	59013	60413	95	57	64501	25
11	37	36	61817	80	23	47
12	60	59	40	63202	45	68
13	84	38	63	25	67	90
14	59107	60506	86	48	90	95912
15	30	29	61909	70	64612	34
16	54	52	32	93	34	56
17	77	75	55	63315	56	78
18	59201	98	77	38	78	66000
19	42	60621	62000	60	64701	22
20	48	45	23	83	23	43
21	71	68	46	63405	45	65
22	95	91	69	28	67	87
23	59318	60714	91	50	89	66109
24	41	37	62114	73	64811	31
25	65	60	37	95	34	53
26	88	83	60	63518	56	74
27	59412	60805	83	40	78	96
28	35	29	62205	62	64900	66318
29	58	58	28	85	22	40
30	82	76	51	63607	44	60

D	36	37	38	39	40	41
M	Parts	Parts	Parts	Parts	Parts	Parts
31	59505	60899	62274	63630	64966	66283
32	29	60922	96	52	89	66305
33	52	45	62319	75	65011	27
34	75	68	42	97	33	49
35	99	91	65	63719	55	70
36	59622	61014	87	42	77	92
37	45	37	62410	64	99	66414
38	69	60	33	87	65121	36
39	92	83	56	63809	43	57
40	59715	61106	78	32	65	79
41	39	29	62501	54	87	66510
42	62	52	24	76	65209	23
43	85	75	46	99	31	44
44	59809	98	69	63921	53	66
45	32	61221	92	43	75	88
46	55	44	62615	66	98	66609
47	79	67	37	88	65320	31
48	59902	90	60	64010	42	53
49	25	61313	83	33	64	74
50	48	36	62705	55	86	96
51	72	59	28	77	65408	66718
52	95	82	51	64100	30	39
53	60018	61405	73	22	52	61
54	42	28	69	44	74	83
55	65	51	62818	67	96	66804
56	88	74	41	89	65518	26
57	60111	97	64	64211	40	48
58	35	61520	86	34	61	69
59	58	43	62909	56	83	91
60	81	66	32	78	65605	66913

D	42	43	44	45	46	47
M	Parts	Parts	Parts	Parts	Parts	Parts
1	66934	68221	69486	70731	71954	73155
2	56	42	69507	51	74	75
3	77	63	28	72	94	94
4	99	84	49	92	72014	73214
5	67021	68306	70	70813	34	34
6	42	27	91	33	55	54
7	64	48	69612	54	75	74
8	85	70	33	75	95	93
9	67107	91	53	95	72115	73313
10	28	68412	74	70916	35	33
11	50	33	95	36	55	53
12	72	45	69716	67	75	72
13	93	75	37	77	96	92
14	67215	97	58	98	72216	73412
15	36	68518	79	71018	26	32
16	58	39	96	39	56	51
17	79	60	66820	59	76	71
18	67301	81	41	79	96	91
19	22	68603	62	71100	72316	73501
20	44	24	83	20	36	30
21	65	45	69903	41	56	50
22	87	66	24	61	77	70
23	67408	87	45	81	97	90
24	30	68708	66	71202	72417	73609
25	51	29	87	23	37	29
26	73	51	70007	43	57	49
27	94	72	28	63	77	68
28	67516	93	49	84	97	88
29	37	68814	70	71304	72517	73708
30	59	35	90	25	37	27

D	42	43	44	45	46	47
M	Parts	Parts	Parts	Parts	Parts	Parts
31	67580	68856	70111	71345	72557	73747
32	67601	77	32	65	77	67
33	23	98	53	86	97	86
34	44	68919	73	71406	72617	73806
35	66	40	94	26	37	25
36	87	61	70215	47	57	45
37	67709	83	36	67	77	65
38	30	69004	56	87	97	84
39	51	25	77	71508	72717	73904
40	73	46	98	28	37	23
41	94	67	70318	48	57	43
42	67815	88	39	69	77	63
43	37	69109	60	89	97	82
44	58	30	80	71609	72817	74002
45	80	51	70401	30	37	21
46	67901	72	22	50	57	41
47	22	93	42	70	76	60
48	44	69214	63	91	96	80
49	65	35	84	71711	72916	74100
50	86	56	70504	31	36	19
51	68008	77	25	51	56	39
52	29	98	45	72	76	58
53	50	69319	66	92	96	78
54	73	40	87	71812	73016	97
55	94	61	70607	32	36	74217
56	68114	82	28	53	55	36
57	35	69403	48	73	75	56
58	56	23	66	93	95	75
59	78	44	90	71913	73115	95
60	99	65	70710	33	53	74314

D	48	49	50	51	52	53
M	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*	*Parts*
1	74333	75490	76623	77732	78818	79881
2	53	75509	41	51	36	98
3	72	28	60	69	54	79916
4	92	47	79	87	72	33
5	74411	66	97	77806	90	51
6	31	85	76716	24	78908	68
7	50	75604	35	42	26	85
8	70	23	53	60	44	80003
9	89	42	72	79	61	20
10	74508	61	91	97	79	38
11	28	80	76809	77915	97	55
12	47	99	28	33	79015	73
13	66	75718	46	52	33	90
14	86	37	65	70	51	80107
15	74605	56	84	88	68	25
16	25	75	76902	78006	86	42
17	44	94	21	24	79104	60
18	63	75813	39	43	22	77
19	83	32	58	61	40	94
20	74702	51	77	79	57	80212
21	21	70	95	97	75	29
22	41	89	77014	78115	93	47
23	60	75908	32	33	79211	64
24	79	27	51	52	28	81
25	99	46	69	70	46	99
26	74818	64	88	88	64	80326
27	37	83	77106	78206	82	33
28	57	76002	25	24	99	51
29	76	21	43	42	79317	68
30	95	12	62	60	35	85

D	48	49	50	51	52	53
M	Parts	Parts	Parts	Parts	Parts	Parts
31	74914	76059	77180	78278	79353	80402
32	34	78	99	97		20
33	53	97	77217	78315	88	37
34	72	76116	36	33	79406	54
35	91	43	54	51	23	72
36	75011	53	73	69	41	89
37	30	72	91	87	59	80506
38	49	91	77310	78405	76	23
39	68	76210	28	23	94	41
40	88	29	47	41	79512	58
41	75107	48	65	59	29	75
42	26	66	84	77	47	92
43	45	85	77402	95	64	80610
44	64	76304	20	78513	82	27
45	83	23	39	31	79600	44
46	75203	42	57	49	17	61
47	22	60	76	67	35	78
48	41	79	94	85	52	96
49	60	98	77512	78603	70	80713
50	79	76417	31	21	88	30
51	99	35	49	39	79705	47
52	75318	44	67	57	23	64
53	37	73	86	75	40	81
54	56	92	77604	93	85	98
55	75	76510	22	78711	75	80816
56	94	29	41	29	93	33
57	75413	48	59	47	79811	50
58	32	67	77	65	28	67
59	51	85	96	83	46	84
60	70	76604	77714	78801	63	80901

D	54	55	56	57	58	59
M	Parts	Parts	Parts	Parts	Parts	Parts
1	80918	81931	82920	83882	84820	85731
2	35	48	36	98	35	46
3	52	65	52	83914	51	61
4	70	81	68	30	66	76
5	87	98	85	46	81	91
6	81004	82015	83001	61	97	85806
7	21	31	17	77	84912	21
8	38	48	33	93	27	36
9	55	65	49	84009	43	51
10	72	81	66	25	58	66
11	89	98	82	40	73	81
12	81106	82114	98	56	89	96
13	23	31	83115	72	85004	85910
14	40	48	30	88	91	25
15	57	64	46	84103	35	40
16	74	81	63	19	50	55
17	91	97	79	35	65	70
18	81208	82214	95	51	81	85
19	25	30	83211	66	96	86000
20	42	47	27	82	85111	14
21	59	64	43	98	26	29
22	76	80	59	84213	42	44
23	93	97	76	29	57	59
24	81310	82313	92	54	72	74
25	27	30	83308	60	87	89
26	43	46	24	76	85203	86103
27	60	63	40	92	81	18
28	77	79	65	84370	33	33
29	94	96	72	23	48	48
30	81411	82412	88	39	64	62

D / M	54 Parts	55 Parts	56 Parts	57 Parts	58 Parts	59 Parts
31	81428	82429	83404	84354	85279	86177
32	45	45	20	70	94	92
33	62	62	36	86	85309	86207
34	79	78	52	84401	24	21
35	95	94	68	63	39	36
36	81512	82511	84	32	55	51
37	26	27	83500	48	70	66
38	46	44	16	63	85	80
39	63	60	32	79	85400	95
40	80	77	48	95	15	86310
41	96	93	64	84510	30	24
42	81613	82609	80	26	45	39
43	30	26	96	41	60	54
44	47	42	83612	57	76	68
45	64	58	28	72	91	83
46	80	75	44	88	85506	98
47	97	91	60	84603	21	86412
48	81714	82708	76	19	36	27
49	31	24	92	34	51	42
50	48	40	83708	50	66	56
51	64	57	24	65	81	71
52	81	73	40	81	69	58
53	98	89	55	96	85611	86500
54	81814	82806	71	84712	26	15
55	31	22	87	27	41	29
56	48	38	83803	34	56	44
57	65	54	19	58	71	58
58	81	71	35	73	86	73
59	98	87	51	89	85701	87
60	81915	82903	67	84804	16	86602

D	60	61	62	63	64	65
M	Parts	Parts	Parts	Parts	Parts	Parts
1	86617	87476	88308	89113	89892	90643
2	31	90	22	27	89904	55
3	90	87504	35	40	17	67
4	60	18	88349	53	30	79
5	75	32	62	89166	43	92
6	89	87546	76	79	89955	90704
7	86404	60	90	92	68	16
8	18	74	88403	89206	81	28
9	33	88	17	19	93	41
10	47	87602	30	32	90006	90753
11	62	16	44	45	19	65
12	76	30	88458	89258	31	77
13	91	44	71	71	44	89
14	86805	87658	85	84	90057	90802
15	19	72	98	97	69	14
16	34	86	88512	89310	82	26
17	48	87700	25	24	95	38
18	63	14	39	37	90107	90850
19	77	28	52	50	20	62
20	91	42	88566	89363	32	75
21	86906	87756	79	76	45	87
22	20	70	93	89	98158	99
23	35	84	88606	89402	70	90911
24	49	98	20	15	83	23
25	63	87812	33	28	95	35
26	78	26	47	41	90208	47
27	92	40	88660	89454	20	90959
28	87006	53	74	67	33	71
29	21	67	87	80	46	84
30	35	87881	88701	89493	90258	96

D	60	61	62	63	64	65
M	Parts	Parts	Parts	Parts	Parts	Parts
31	87049	87895	88714	89506	90271	91008
32	64	87909	27	19	83	20
33	78	23	41	32	96	32
34	92	37	54	45	90308	44
35	87107	51	88768	89558	21	91056
36	21	87964	81	71	33	68
37	35	78	94	84	46	80
38	94	92	88808	97	90358	92
39	64	88006	21	80609	70	91104
40	87	20	35	22	83	16
41	92	33	48	35	95	28
42	87206	47	88861	48	90408	40
43	21	88061	75	89651	20	91162
44	35	75	88	74	33	64
45	49	89	88901	87	45	76
46	63	88102	15	89700	90457	88
47	78	16	28	12	70	91200
48	92	30	41	25	82	12
49	87306	44	88954	38	95	23
50	20	88157	68	89751	90507	35
51	34	71	81	64	19	91247
52	48	85	94	77	32	59
53	63	98	89008	89	44	71
54	77	88212	21	89802	90556	83
55	91	26	34	15	69	95
56	87405	40	47	28	81	91307
57	19	53	89060	41	93	19
58	33	88267	74	89853	90606	30
59	47	81	87	66	18	42
60	61	94	89100	79	30	91354

D	66	67	68	69	70	71
M	Parts	Parts	Parts	Parts	Parts	Parts
1	91366	92061	92729	93368	93979	94561
2	78	73	40	78	89	70
3	90	84	51	89	99	80
4	91401	95	61	99	94009	89
5	13	92107	62772	93410	18	99
6	25	18	83	20	28	94608
7	37	29	94	30	38	17
8	91448	41	92805	41	48	27
9	60	92152	16	93451	94058	36
10	72	63	26	61	68	47
11	84	75	37	72	78	94655
12	95	86	92848	82	88	64
13	91507	97	59	92	97	74
14	19	92208	70	93503	94107	83
15	31	20	80	13	17	93
16	42	31	91	23	27	94702
17	91554	42	92902	34	37	11
18	66	92253	13	93544	74	21
19	77	65	24	54	94156	30
20	89	76	34	64	66	39
21	91601	87	92945	75	76	94748
22	12	98	56	83	86	58
23	24	92309	66	95	95	67
24	37	21	77	93605	94205	76
25	91647	32	88	16	15	86
26	59	43	99	26	25	95
27	71	92354	93009	36	34	94804
28	82	65	20	46	44	13
29	94	76	31	57	94254	23
30	91706	92387	93041	67	64	32

D	66	67	68	69	70	71
M	Parts	Parts	Parts	Parts	Parts	Parts
31	91717	92329	93052	93677	94273	94841
32	29	92410	62	87	83	50
33	40	21	73	97	93	60
34	52	32	84	93707	94302	69
35	91763	43	94	18	12	94878
36	75	92454	93105	28	22	87
37	87	65	16	38	31	96
38	98	76	26	93748	41	94905
39	91810	87	37	58	94351	15
40	21	98	93147	68	60	24
41	33	92509	58	78	70	33
42	44	20	69	88	80	42
43	91856	32	79	98	89	51
44	67	43	90	93809	99	94960
45	79	92554	93200	19	94408	69
46	90	65	11	29	18	79
47	91902	76	21	39	28	88
48	13	87	32	93849	37	97
49	24	98	93242	59	47	95006
50	36	92609	53	69	94456	15
51	91947	20	63	79	66	24
52	59	30	74	89	75	33
53	70	41	84	99	86	42
54	82	92652	95	93909	94	51
55	39	63	93305	19	94504	95060
56	92004	74	16	29	13	69
57	16	85	26	39	23	78
58	27	96	37	93949	32	87
59	39	92707	47	59	42	96
60	92050	18	93358	69	94551	95105

D	72	73	74	75	76	77
M	Parts	Parts	Parts	Parts	Parts	Parts
1	95114	95638	96134	96600	97036	97443
2	23	47	42	07	43	50
3	32	55	50	15	50	96
4	41	64	58	22	75	63
5	50	95672	66	30	64	69
6	95159	81	74	37	97071	76
7	68	89	82	45	78	82
8	77	98	90	52	85	89
9	86	95706	98	60	92	95
10	95	15	96205	67	99	97502
11	95204	23	13	74	97106	08
12	12	31	21	82	13	14
13	21	40	29	89	20	21
14	30	95748	37	97	27	27
15	39	57	96145	96704	34	97534
16	95248	65	53	11	97141	40
17	57	73	61	19	48	47
18	66	95782	69	26	54	53
19	74	90	96277	34	61	59
20	83	98	84	96741	97168	97566
21	92	95807	92	48	75	72
22	95301	15	96300	56	82	78
23	10	23	08	63	89	85
24	19	32	16	70	96	91
25	27	40	24	96778	97202	98
26	36	95848	96331	85	09	97604
27	45	57	39	92	16	10
28	54	65	48	96800	23	16
29	62	73	55	07	30	23
30	95371	95881	96363	14	97236	97629

D	72	73	74	75	76	77
M	Parts	Parts	Parts	Parts	Parts	Parts
31	95380	95890	96370	96822	97243	97635
32	89	98	78	29	50	42
33	97	95906	86	36	57	48
34	95406	14	94	43	64	54
35	15	23	96401	51	70	60
36	95424	31	09	96858	97277	67
37	32	39	17	65	84	97673
38	41	95947	24	72	91	79
39	50	56	32	79	97	85
40	95458	64	96440	87	97304	92
41	67	72	48	94	11	98
42	76	95980	55	96901	17	97704
43	84	88	63	08	24	10
44	93	96	96471	15	31	16
45	95501	96004	78	23	97337	23
46	10	13	86	30	44	29
47	19	21	94	96937	51	97735
48	27	29	96501	44	57	41
49	36	37	09	51	64	47
50	95545	96045	16	58	97371	53
51	53	53	24	65	77	60
52	62	61	96532	96973	84	97766
53	70	69	39	80	90	72
54	79	96077	47	87	97	78
55	95587	85	54	94	97404	84
56	96	94	62	97001	10	90
57	95604	96102	96599	08	17	96
58	13	10	77	15	23	97802
59	21	18	85	22	30	08
60	30	26	96592	97029	97437	14

D	78	79	80	81	82	83
M	Parts	Parts	Parts	Parts	Parts	Parts
1	97820	98168	98485	98773	99030	99258
2	26	73	90	77	34	61
3	32	79	95	82	38	65
4	38	84	98500	86	42	68
5	44	90	05	91	46	72
6	98850	95	10	98795	99050	99275
7	56	98201	15	98800	54	79
8	62	06	20	04	58	82
9	68	12	98525	09	62	85
10	74	17	30	13	66	89
11	97880	22	35	18	99070	99293
12	86	98228	40	98822	74	96
13	92	34	45	27	78	99300
14	98	39	98550	31	82	03
15	97904	45	55	36	86	06
16	10	50	60	40	99090	10
17	16	98255	65	98844	94	13
18	22	61	70	49	98	99317
19	28	66	98575	53	99102	20
20	97934	72	80	58	06	22
21	39	77	85	62	09	27
22	45	98282	89	98866	13	30
23	51	88	94	71	17	99333
24	57	93	99	75	99121	37
25	97963	98	98604	79	25	40
26	69	98304	09	84	29	43
27	75	90	14	98888	33	47
28	80	14	18	92	36	99350
29	86	20	23	97	40	53
30	97992	98325	98628	98901	99144	57

D	78	79	80	81	82	83
M	Parts	Parts	Parts	Parts	Parts	Parts
31	97998	98330	98633	98905	99148	99360
32	98004	36	38	10	52	63
33	09	41	42	14	55	67
34	15	46	47	18	59	70
35	21	51	52	22	63	73
36	27	98357	98657	98927	99167	99376
37	98032	62	61	31	70	80
38	38	67	66	35	74	83
39	44	72	71	39	78	86
40	50	78	76	44	82	89
41	55	98383	98680	98948	99185	99392
42	98061	88	85	52	89	96
43	67	93	90	56	93	99
44	72	98	94	60	96	99402
45	78	98404	99	65	99200	05
46	84	09	98704	98969	04	08
47	89	14	08	73	07	11
48	95	19	13	77	11	15
49	98101	24	18	81	15	99418
50	06	98429	22	85	99218	21
51	12	34	98727	98990	22	24
52	18	40	32	94	25	27
53	23	45	36	98	29	30
54	98129	50	41	99002	33	99433
55	34	98455	45	06	99236	36
56	40	60	98750	10	40	29
57	46	65	55	14	44	43
58	51	70	59	18	47	46
59	57	75	64	22	51	99449
60	62	98480	98768	99025	99256	52

D	84	85	86	87	88	89
M	Parts	Parts	Parts	Parts	Parts	Parts
1	99455	99622	99758	99864	99939	99985
2	58	24	60	65	40	85
3	61	27	62	67	41	86
4	64	29	64	68	42	86
5	67	32	66	70	43	87
6	99470	99934	99768	99871	99944	87
7	73	37	70	73	45	88
8	76	39	72	74	45	99988
9	79	41	74	76	46	88
10	82	44	76	77	47	89
11	99485	99646	99778	99878	99948	89
12	88	49	80	79	49	90
13	91	51	82	80	50	90
14	93	54	83	82	51	99991
15	96	56	85	83	52	91
16	99	99658	99787	99884	99953	91
17	99502	61	89	86	54	92
18	05	63	91	88	55	92
19	08	66	93	90	55	92
20	11	68	95	91	56	99992
21	14	99670	99797	99893	99957	93
22	99517	73	99	94	58	93
23	19	75	99800	95	59	94
24	22	77	02	97	60	94
25	25	80	04	98	61	94
26	28	99682	06	99	99961	99995
27	99531	84	08	99900	62	95
28	34	87	99809	02	63	95
29	36	89	11	03	64	
30	39	91	13	99904	99964	

D	84	85	86	87	88	89
M	Parts	Parts	Parts	Parts	Parts	Parts
31	99542	99694	99815	99906	99965	99996
32	45	96	17	07	66	96
33	47	98	18	08	67	96
34	50	99700	20	09	67	97
35	53	03	22	11	68	97
36	99556	05	99823	99912	99969	97
37	58	07	25	13	70	99997
38	61	09	27	14	70	97
39	64	99711	29	15	71	98
40	67	14	30	17	72	98
41	99569	16	99832	99918	99972	98
42	72	18	34	19	73	98
43	75	20	35	20	74	99998
44	77	99722	37	21	74	98
45	80	25	39	22	75	99
46	99583	27	99840	99924	99976	99
47	85	29	42	25	76	99
48	88	31	44	26	77	99
49	91	99733	45	27	78	99999
50	93	35	47	28	78	99
51	99596	37	99848	99929	79	99
52	98	39	50	30	80	99
53	99601	42	52	31	81	99
54	04	99744	53	32	81	99
[illegible]	06	46	55	33	82	99999
[illegible]		48	99856	99934	99982	99
[illegible]		50	58	35	83	99
57		52	59	37	83	99
[illegible]		54	61	38	84	100000
[illegible]		56	62	99939	99984	100000

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